THE

FOUNDRY TRADE JOURNAL

WITH WHICH IS INCORPORATED

THE IRON AND STEEL TRADES JOURNAL

VOL. 47. Thursday, November 3, 1932. No. 846.

PUBLISHED WEEKLY.

Subscription Terms: 15s. per annum.
Foreign and Colonial: 17s. 6d. per annum.
All Subscriptions are payable in advance.

All Communications to be addressed to the Editor, the Advertisement Manager, or the Publisher of
THE FOUNDRY TRADE JOURNAL,
49, WELLINGTON STREET, LONDON, W.C.2.
Telegraphic Address: "Zacatecas, Rand, London."
Telephone: Temple Bar 3951 (5 lines).

Contents.

	PAGE
Forthcoming Events	261
British Cast Iron Research Association: Annual Meeting	261, 267
Is "Foundryman" an Americanism?	261
Correspondence	262
New British Chemical Standard Cupro-Nickel "A"	262
Heat-Resisting Metals and their Use in the Ceramic Industry	263
Some Observations on the Character of Cast Iron	266
Foundry Problems	270
Works Management	273
This Week's News in Brief	274
Trade Talk	274
Personal	274
Obituary	274
Contracts Open	274
Raw Material Markets	276
British Foundry Units, Limited	276

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN; THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES' EQUIPMENT AND SUPPLIES ASSOCIATION.

Institute of British Foundrymen.

PRESIDENT: 1932-33:
Victor Stobie, M.I.E.E., Langholm, South Drive, Harrogate.

LIST OF SECRETARIES—
General Secretary: T. Makemson, Saint John Street Chambers, Deansgate, Manchester. London Office: 49, Wellington Street, London, W.C.2.
Birmingham, Coventry and West Midlands: L. W. Bolton, 21-23, St. Paul's Square, Birmingham.
Sheffield: T. R. Walker, 33, Ladysmith Avenue, Nether Edge, Sheffield.
Scottish: J. Bell, 60, St. Enoch Square, Glasgow.
Lancashire: J. E. Cooke, 1, Derbyshire Crescent, Stretford, Manchester.
London: H. W. Lockwood, Stewarts & Lloyds, Limited, Winchester House, Old Broad Street, London, E.C.2.
Newcastle-upon-Tyne: J. W. Eckford, 4, Mosley Street, Newcastle-upon-Tyne.
East Midlands: H. Bunting, 82, Otter Street, Derby.
West Riding of Yorkshire: S. W. Wise, 110, Pullan Avenue, Eccleshill, Bradford.
Wales and Monmouth: J. J. McClelland, 12, Clifton Place, Stow Hill, Newport, Mon.
Middlesbrough: F. A. Harper, "The Briars," Bishopton Road, Stockton-on-Tees.

Foundry Trades' Equipment and Supplies Association.

President: D. H. Wood,
Titan Works, Charles Henry Street, Birmingham.
Secretary: K. W. Bridges, Grand Buildings, Trafalgar Square, London, W.C.2.

Welsh Engineers' and Founders' Association.

Secretary: E. J. Griffiths, 2, Royal Metal Exchange, Swansea.

BRITISH CAST IRON RESEARCH ASSOCIATION.

The Registered Office and Laboratories of the B.C.I.R.A. are at:—
21-23, ST. PAUL'S SQUARE, BIRMINGHAM.
Telephone: Central 1858. Telegrams: CIRA.
The B.C.I.R.A. Scottish Laboratories are:—
Foundry Technical Institute, Meek's Road, Falkirk (Telephone 332).

Forthcoming Events.

NOVEMBER 10.

Institute of Metals (London Local Section):—Ordinary meeting. "Non-Ferrous Metals and Alloys in Railway Engineering," Paper by Sir Henry Fowler, K.B.E., D.Sc.

Institute of Metals (Swansea Local Section):—Ordinary meeting. "Some Stainless Alloys," Paper by L. B. Pfeil, D.Sc.

Institute of British Foundrymen.

NOVEMBER 5.

East Midlands (Lincolnshire Section):—Ordinary meeting. "High-Strength Light Alloys," Paper by W. C. Devereux.

Lancashire Branch:—Ordinary meeting. "Contraction, Distortion and Camber in Grey-Iron Castings," Paper by E. Longden.

Scottish Branch:—Ordinary meeting at Glasgow. "Plaster Patterns in General Foundry Practice," Paper by Robert Ballantine.

British Cast Iron Research Association.

The report of the Council of the British Cast Iron Research Association presented at the annual meeting in London yesterday forms much more satisfactory reading than might have been anticipated from the rather depressing note on which the year opened. At that date—July, 1931—a new basis for the payment of Government grant came into operation, which necessitated a material increase both in new members and in subscription rates, and the steady deepening of the depression made the realisation of the desired amount rather problematical. Fortunately, during the year, the Department of Industrial and Scientific Research was able on the advice of its Advisory Council to modify the original terms to some extent. The net result has been a material diminution of grant and a much smaller drop in total income, but the grant and industrial income combined have sufficed to enable the Association to carry on.

The other important event at the close of the year was the opening by Lord Rutherford of Nelson of the new laboratories, which offer much better facilities than have been previously available. In spite of the difficulties the Association has experienced in purchasing equipment, essentially a capital charge, out of income, it is better equipped and accommodated now than at any previous time, and on these two counts there is ample cause for congratulation on the result of the year's working.

It is desirable, however, that the industry should give thought to the future. The arrangement referred to above by the Department of Industrial and Scientific Research relaxing grant terms was of a temporary character, only designed to give a little breathing space for the year just closed and the current financial year. In June, 1933, the question of the future will again crop up, and it is possible that the Department will revert to the original grant terms, which require a subscription income from the industry of £7,500 per annum in order to earn a grant of £2,500 per annum, or alternatively a subscription income of £10,000 per annum to earn a grant of £5,000 per annum. Considering the smaller amount required from the industry, this is only about £1,000 a year more than that now being obtained, and it is inconceivable that it should not be forthcoming, particularly in view of the fact that the industry is now fully protected and is able to command the home market without fear of foreign competition. However, arrangements which require to mature next June should be put in hand without delay, and we hope that the Association will enjoy an accession of membership which will put the financial aspect beyond any doubt.

We give the text of the annual report elsewhere, and have previously dealt with the equipment and accommodation now provided, so that the industry is fully informed as to the facilities available.

Is "Foundryman" an Americanism?

Re-examining the earliest issues of THE FOUNDRY TRADE JOURNAL, before the creation of the Institute of British Foundrymen, we were impressed by the complete absence of the word "foundryman." Its first appearance is as a signature to a letter to the Editor, and was perhaps, as are so many *nom-de-plumes*, a coined word. We then referred to Webster, as being a standard dictionary, and we found no such word as "foundryman." Other dictionaries vouchsafed no further information. About this time, 1902, the American Foundrymen's Association was formed, and foundry technicians acquired the habit of seeing this word constantly in print, and usage, especially after the creation of the British Foundrymen's Association became common. We have asked some of the older people connected with the foundry industry whether they used the word "foundryman" in their youth. Some seem positive that the word has been current in their lifetime, whilst others are not at all sure. In some cases the addition of the word "man" is regarded as being derogatory. When we were at the University, our colleague, Dr. Z. T. K. Woo, then a Chinese metallurgical student, was insistent that his nationals objected strenuously to the appellation "Chinaman" as being of a discourteous character. A man from Rotterdam prefers being called Dutch to a Dutchman. Moreover, we think the owners and principal executive officers of the foundry industry would prefer being referred to as founders rather than foundrymen. There is no French equivalent to foundryman, but we imagine we have seen somewhere the German phrase "giessereimann," and it may be that the Americans evolved the word "foundryman" from this source. Even if they did, it would refer, we should imagine, to a workman, as the technical staff is embraced by the word "fachleute." If any of our readers can throw any light on this subject, we shall indeed be grateful.

C

XUM

Correspondence.

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

A Conservative Industry.

To the Editor of The Foundry Trade Journal.

Sir,—I have read with great interest the remarks on the address made by Mr. Lambert, Mr. Lake and Mr. Blackwell, and, if permitted, I should like to refer to a number of the points raised by these gentlemen. I also wish to congratulate Mr. Sommerfield on his address, which was most illuminating.

The question of reorganising a foundry in particular is one which requires the most careful consideration, and I am convinced that such reorganisation is better done by an outside advising engineer than by any inside works official and for the following reasons: (*a*) The most pressing duty of an executive official is to get on with his job of producing castings as well and as cheaply as possible; (*b*) no official can be expected to know all the latest methods and devices which are most suitable for his particular production; (*c*) no official has time to interview every salesman who may call on him to sell him any particular plant or piece of machinery he may or may not want; (*d*) no official can easily find the time to search all over this country and possibly also the Continent to inspect the suitability of such machinery for his particular requirements.

For these and many other reasons it is surely preferable and advisable that foundries should employ periodically an engineer of admitted experience to report for them on any particular problem which they desire to improve, extend or reorganise.

In every modern foundry there are more and more such problems to consider. There is no sense or reason in any foundry adopting any special plant or machine because some other foundry has done so. Every problem calls for a special individual solution.

Such general knowledge is not necessarily possessed by any particular foundry, and therefore it will always pay to engage the services of an engineer who over a period of years has been able to accumulate such general knowledge by constant visits to foundries of all sorts spread over all Europe, and especially one who has also, through association with foundry-plant experts and international foundry owners, had access to plant works and foundries specialising in the solution of such problems.

There are in this country very few men or companies which can claim such general knowledge or who enjoy the confidence of the foundry industry, but such men can no doubt be found, as in most cases "the need supplies the man."

To those who have constantly visited foundries all over Europe it is always a matter of pride to feel that we are still predominant in foundry handicraft and that, whilst we do not rush into every new fashion, we do select and adopt all that is best to enable us to keep in line with, if not ahead of, the best foundry production in the world.

Mr. Lake very soundly fixes the relative position which should exist as between metallurgist and foundry manager. I personally think that the ideal is to train men who combine a knowledge of chemistry and metallurgy with practical founding, so that our foundry managers would themselves possess all the knowledge necessary to take entire charge of a foundry, both scientifically and practically. Such men are undoubtedly being trained in dozens, if not hundreds, in the technical colleges and universities of Germany in particular, but such a course of education, to be complete, is as long and as strenuous as for any other recognised profession.

Mr. Blackwell refers particularly to the mechanisation of foundries and shows that in his case it has been successful, but great care should be exercised not to overdo this, as over-mechanisation as a cure is sometimes worse than the complaints. Jobbing foundries in particular should be very careful before they mechanise in any direction, whereas multiple-production foundries cannot to-day produce economically in competition without it. Every foundry problem in this sense calls for a special solution.

When well-deserved prosperity comes back to the foundry industry of this country many obsolete and redundant foundries will no doubt have been weeded out, and those remaining will claim the high position in scientific engineering which ought to have been their right for the last century.—Yours, etc.,

John A. Smeeton.

15, Victoria Street,
London, S.W.1.

[This letter has been abridged somewhat.—Editor.]

A Proposed Foundry Technical College.

To the Editor of The Foundry Trade Journal.

Sir,—Dr. Skerl has suggested that I, as an ex-student of Sheffield University, should be more familiar with the work carried out in its metallurgical department, and moreover should be more appreciative of its worth as a training ground for foundry technicians. I claim to be both cognisant of and enthusiastic about the work done and tuition given in this department, but 12 years' close collaboration with the foundry industry has impressed upon me the desirability of separating foundry technology from pure metallurgy, especially that of steel. Dr. Skerl refers to the local non-ferrous foundry industry as being of outstanding importance. Ryland's Directory shows that there are about 384 brass foundries in Birmingham itself and about 50 in the Sheffield area. It takes 12 columns of this book to enumerate the iron founders of Staffordshire, Warwickshire and Worcestershire, whilst three would take care of Sheffield, Chesterfield and Rotherham. Yet it is not only on these grounds that I put forward the claims of Birmingham University, but I coupled them with tradition, for it bears exactly the same relation to cast iron as Sheffield does to steel; and cast iron predominates in the world of active foundry technology, judged by the world's specialised Press. Dr. Skerl's admitted impartial advocacy of the merits of Sheffield University is exactly a parallel with my own when I put forward the potentialities of Birmingham. Obviously, if it were at all possible for me as an appreciative old student, I would, with all the power at my command, have advocated Sheffield.—Yours, etc.,

Vincent C. Faulkner.

Kenton, Middlesex.

To The Editor of The Foundry Trade Journal.

Sir,—I have read with great interest the original article by Mr. V. C. Faulkner and the subsequent correspondence on the subject of a special foundry technical college.

The letter from Dr. Ingall in your issue of October 13 gave an outline of the full-time day foundry course extending over two years which he was able to found at this college in Middlesbrough. The course is a very comprehensive one, the equipment is modern, the staff is in being, students have been kept in touch with the work of the local foundries and some of them have spent the summer vacation in German foundries. Exhibits representing the work done during the course were sent to the International Foundry Exhibitions at Milan and at Paris. The credit for the inception of such a course is due entirely to Dr. Ingall.

Mr. Faulkner places "tradition" first in order of importance amongst the factors to be considered in building up a new foundry college. May I respectfully suggest that foundry work has suffered far too long from tradition and should look to the future rather than the past. The fundamental work of Turner and Carpenter will always be honoured in the systematic study of cast iron, no matter where that study is carried out.

The shortage of well-trained and well-educated men to carry foundry work forward is not due to the absence of facilities for training but to the absence of material to train. If £100,000 were spent as Mr. Faulkner suggests in establishing a new college, there might still be no students. I would suggest that the Institute of British Foundrymen set aside a much smaller sum, immediately, for the award of scholarships to secondary school leavers to enable them to attend a full-time course already in existence. They could then watch, at comparatively little expense, the effect of such training and would be in a position to judge whether the demand is likely to justify the £100,000 scheme.—Yours, etc.,

Thos. J. Murray,
Principal.

Constantine Technical College,
Middlesbrough.
October 31, 1932.

High-Frequency Furnaces.

To the Editor of The Foundry Trade Journal.

Sir,—I recently learned that a special "valve" had now been developed which will replace the costly high-frequency generator used in connection with the above steel furnaces. I would be thankful if your readers could advise me whether the above information is correct, and, if so, give the approximate cost and life of the valve and, further, the greatest capacity furnace capable of being operated by same.

I would greatly appreciate any information concerning the above matter. Thanking you in anticipation,—Yours, etc.,

J. Coutts.

c/o Charles Ruwolt Pty., Limited,
Victoria Street, Richmond, E.1,
Victoria, Australia.
September 27, 1932.

New British Chemical Standard Cupro-Nickel "A."

It is announced that a new non-ferrous standard cupro-nickel has been made available having the following analysis:—Copper, 68.85; nickel, 30.08; silicon, 0.12; manganese, 0.89; iron, 0.05; magnesium, 0.027; carbon, 0.02; sulphur, 0.01; lead, not above 0.01; and cobalt, not above 0.01 per cent. This sample will serve as a standard for the analysis of cupro-nickel sheets and strip referred to in the British Standard Specification No. 374-1930. It may be used also checking the analysis of the following cupro-nickel alloys:—Condenser tubes, bullet envelopes, coinage, electrical rheostats and resistances, base-metal thermocouples, and domestic utensils. It is believed that this is the only standard of its kind issued in either Great Britain, U.S.A., or the Continent, and it is therefore likely to be of international interest.

As usual the standard turnings have been analysed by a number of chemists representing the different interests involved, viz.: independent analysts, government dept., railway chemist, cupro-nickel manufacturers and users.

The standard is issued in bottles containing 500 grms., 100 grms. and 50 grms., and each bottle is provided with a certificate showing the detailed analysis of each chemist together with an outline of the methods used. It is issued at a price which is estimated to eventually cover the cost and may be obtained from Ridsdale & Company, British Chemical Standards Headquarters, 3, Wilson Street, Middlesbrough, or from Laboratory Furnishers.

Heat-Resisting Metals and their Use in the Ceramic Industry.*

By J. Ferdinand Kayser (Chief Metallurgist of Darwins, Limited).

The products of the ceramic industry are many and varied, and each branch of the industry is characterised by operations peculiar to it. In every branch there is, however, one or more operations which depend upon high temperatures and in which parts made from heat-resisting metals may be economically utilised. Not only may they be used to replace wrought or cast-iron parts whose life must necessarily be short, but they may be put to uses for which units made from ordinary metals are totally unfitted.

The conditions under which heat-resisting alloys are required to work vary to an enormous extent, not only in regard to temperature but also in regard to the atmospheric conditions and the stress to which they are subjected. Consequently a number of different heat-resisting alloys have been developed, each with its own peculiar characteristics. In order to be able to judge whether or not a heat-resisting metal may be economically applied for any particular purpose, and, if so, to choose the best possible metal for that purpose, it is necessary thoroughly to appreciate the nature of the conditions under which the metal will have to work, the properties of metals at high temperatures in general, and the properties of the available heat-resisting metals in particular.

Essential Characteristics.

The essential characteristic of a heat-resisting metal is surface stability at high temperatures. Fortunately, surface stability is attainable comparatively easily, and the stability of metal surfaces can be tested with equal facility. In this communication the author intends only to consider metals suitable for use at 700 deg. C. and upwards, and it is consequently not necessary to consider what is usually referred to as rusting, but only to consider the resistance of metals to what is generally called oxidation or scaling. It is not proposed to enter into a long discussion of what constitutes oxidation or scaling, and for the purpose of the present communication it is considered that an alloy resists such action if at the particular temperature at which it is tested, the cross-section of unaltered metal is not appreciably affected, and if corners of machined or ground samples maintain their original sharpness. It is not necessary that the surface of the metal remain bright and untarnished.

One might expect that with increase in temperature the rate of oxidation would gradually increase, but fortunately that is not the case. There is a certain critical temperature below which the rate of oxidation is so low as to be inappreciable, and it is that temperature to which the author refers as "scaling temperature." The time factor must, of course, be considered to some extent, but it has been definitely established that if an alloy will resist oxidation as defined above for not less than 12 hrs., then for all practical purposes the metal may be said to have a stable surface at the temperature in question.

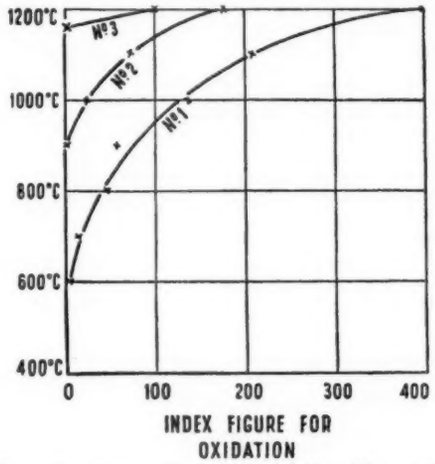

Fig. 1.—Curve No. 1—C, 0.17; Mn, 0.67. Curve No. 2—C, 0.12; Cr, 17.74; Ni, 8.06. Curve No. 3—C, 0.7; Ni, 57.0; Cr, 15.0.

Test Procedure.

The author's tests are carried out in an automatically-controlled electric furnace, and consist in maintaining suitable samples for 18 hrs. at 700 deg. C. and then removing them from the furnace and examining their surfaces. Samples showing no signs of scale are returned and maintained at 750 deg. C. for a further 18 hrs. and again examined. The test is continued until ultimately a temperature is found at which scaling has set in and the scaling temperature is then reported as being between that particular temperature and a temperature 50 deg. lower, *i.e.*, and alloy which does not show signs of scaling at 1,200 deg. C. but does show signs of scaling at 1,250 deg. C. is reported as having a scaling temperature lying between 1,200 deg. C. and 1,250 deg. C.

Even mild steel has a reasonably well-defined scaling temperature, but as the resistance of the metal is increased by suitable change of composition, the scaling temperature becomes more sharply defined. This is well illustrated in Fig. 1, where index figures for oxidation are plotted against temperature. The two lower curves are from results obtained by Dr. W. H. Hatfield,[1] whilst the third curve (for Alloy 5, Table I) has been determined by the author. Dr. Hatfield's samples were approximately 1 cm. in dia. and weighed about 20 grams, and the index figure for oxidation is the increase in weight in milligrams per square centimetre of surface.

Dr. Hatfield's nickel-chromium steel, containing 8 per cent. nickel and 18 per cent. chromium, is essentially a stainless steel, and its real field of use is at temperatures below 700 deg. C. It has, however, considerable resistance to oxidation at high temperatures and is used to some extent for heat-resisting purposes.

An oxidising atmosphere is not, however, the most dangerous. Reducing atmospheres containing sulphur dioxide or sulphuretted hydrogen are the most dangerous atmospheres with which heat-resisting alloys have to contend. It has not yet been established what is the permissible percentage of sulphur dioxide or sulphuretted hydrogen that the different alloys can withstand, but it is known that when the sulphur content of the original fuel exceeds some 1.5 to 2 per cent. the life of alloys containing more than about 25 per cent. nickel, is very seriously shortened, whereas nickel-free heat-resisting alloys are completely immune from attack. Nickel alloys which have been attacked by sulphur fumes are always covered with a brittle scale which frequently shows signs of having been molten, although the furnace temperature may not have exceeded 900 deg. C., and on occasion buttons of the scale have been found on furnace floors. The following analysis[2] of such scale is typical:—Fe, 11.2; Ni, 40.5; Cr, 10.4; S, 4.3 per cent.; C, nil.

Reference to the nickel-sulphur thermal-equilibrium diagram shows that the addition of sulphur to nickel lowers the liquidus and there is a eutectic composition approximating very closely to Ni_3S, which has a melting point of 644 deg. C. If sulphur comes in contact with a nickel alloy, it is quite conceivable that NiS (one of the constituents of the eutectic) will be formed and will ultimately reduce the melting point of the surface to the furnace temperature which may be well below, say, 1,000 deg. C.

All nickel alloys, except those containing aluminium, are liable to sulphur attack. In general the higher the nickel the greater the probability that sulphur attack will commence, but different casts of the same composition do not always behave the same when tested side by side in a sulphurous atmosphere. Oxidation or scaling in air always commences at a definite temperature depending upon the composition of the alloy, but there is no definite scaling temperature in sulphurous atmospheres and failure is likely to occur at any temperature above 700 deg. C. if the concentration of sulphur is sufficiently high.

Tensile Strength and Time Factor.

There is nothing peculiar about the tensile strength of heat-resisting metals at atmospheric temperatures. There is, however, no relationship between the tensile properties of metals at atmospheric temperatures and the corresponding properites at elevated temperatures. At atmospheric temperatures alloys and metals have physical properties characteristic of a solid. At

Table I.—*Mechanical Properties of Alloys at Elevated Temperatures.*

No.	C.	Ni.	Cr.	Atmospheric temp.				800° C.			900° C.*			1,000° C.*			Test sample.
				Yield stress. Tons per sq. in.	Max. stress. Tons per sq. in.	Elongation per cent. on 2 in.	Reduction of area per cent.	Max. stress.	Elongation per cent.	Red. area per cent.	Max. stress.	Elongation per cent.	Red. area per cent.	Max. stress.	Elongation per cent.	Red. area per cent.	
1	0.9	66	21	21	28	2.5	2.4	9.4	6	5.6	5.7	8	9.6	3.6	7.5	16	Cast bar
2	0.8	60	20	24	31	1.5	1.4	11.8	8	4.8	7.5	8.5	4.8	5.3	11	9.6	Cast bar
3	1.4	30	30	—	21.3	Nil	Nil	13.6	1.5	1.1	9.4	3.0	3.2	7.1	8	8	Cast bar
4	0.8	Nil	28	—	25	Nil	Nil	5.3	11	25.2	3.9	15.5	40.0	2.4	26.5	53	Cast bar
5	0.7	57	15	16	29	18	58	12	38	42	9.5	28.5	26.4	4.4	31	27.2	Rolled sheet
6	0.5	21	14	45	56	22	38	9.9	21.5	55.2	5.8	38	57.3	4.7	57.5	59.6	Rolled bar
7	0.3	Nil	28	30	65	12	31	4.87	49.5	86.05	V. low	—	—	V. low	—	—	Rolled bar

* Rate of Loading: 44 lb. per min.

* A Paper read before the Ceramic Society and published by kind permission of the Council.

elevated temperatures, however, the nature of their physical properties undergoes a complete change and they become somewhat similar to those of an exceedingly viscous fluid. Consequently the time factor plays an important part in the results obtained. It is a simple matter to heat a test-piece whilst it is in the testing machine and to determine its apparent tensile strength. If the test is carried out at the normal rate of loading the stress-strain diagram will be somewhat similar to that obtained from a cold test-piece, but there will be no definitely defined yield point.

Table I shows the composition and tensile strength at atmospheric and elevated temperatures of seven different heat-resisting alloys. The rate of loading adopted at elevated temperatures was considerably lower than that usual in tensile tests, but was, nevertheless, comparatively rapid. An increase in the rate of loading gives an increased reading for maximum stress. In the case of alloy No. 3, increasing the rate of loading from 44 lbs. per min. to 44 lbs. per 20 secs. caused an increase in maximum stress of 24 per cent. The maximum stress figures given by such a test are, however, useless even for comparison purposes. For instance, at 1,000 deg. C. two alloys which broke under a load of 4.34 tons per sq. in. and 5.7 tons per sq. in. respectively when the rate of loading was 44 lbs. per min., broke under a constant load of 3 tons per sq. in. in 2¼ hrs. and 4¼ hrs. respectively.

The extent to which time enters into high-temperature tests was not thoroughly appreciated until the publication of Dickinson's Paper[3] to the Iron and Steel Institute in 1922. Since that time a new technique in mechanical testing at high temperatures has been developed, but in spite of the large amount of work that has been done, the real nature of the physical properties of metals at high temperatures is not yet properly understood. It is, in fact, doubtful if the real nature of the tensile properties of metals at ordinary temperatures was appreciated until the publication of Dickinson's aforementioned Paper.

The phenomena encountered in testing a sample of very hard steel are, comparatively speaking, simple. The test-piece will ultimately rupture without appreciable change of dimensions and the elastic limit and the maximum stress coincide. In the case of a ductile metal the phenomena encountered are, however, rather more complex. When the yield point has been definitely passed any increase in stress causes a reduction in area of the test-piece and the stress per unit area necessarily increases at a greater rate than the increase in actual load. If there were no such thing as strain hardening it is obvious that the test-piece would continue to elongate at an increasing rate until rupture occurred.

At normal temperatures, however, practically all known metals do strain-harden or work-harden to a considerable extent, and in the case of a ductile metal there is a considerable range between the yield point and the maximum stress in which stability of dimensions may be attained. Dr. Hatfield[4] has shown that even at ordinary temperatures, above the elastic range, yielding takes place with time, and that a mild-steel test-piece stressed 6 tons above its yield point at 15 deg. C. did not attain stability in dimensions until 22 hrs. had elapsed. The strain-time curve for a metal subjected to a stress between the elastic limit and the maximum stress is as shown in Fig. 2, Curve 1. The metal which has flowed becomes less and less likely to flow, and the curve is definitely concave downwards.

As the temperature increases the properties of metals gradually change until ultimately a point is reached where, if the stress is sufficiently high, the sample elongates with increasing rapidity until fracture ultimately occurs. The strain-time curve is then as shown in Fig 2, Curve 2, the latter portion becoming concave upwards. According to Chevenard[5] this change of direction is not explained, quantitively, solely by the increase of the load per unit area due to the reduction in area of the test-piece, and he concludes that, under certain conditions, metal which has flowed becomes more likely to flow.

Before heat-resisting metals can be applied with confidence, in the same way that alloy steels can be applied to, say, automobile design, an answer must be given to the question: "What is the maximum load that a given alloy can sustain at any given elevated temperature over a long period without change or dimensions?" The term "long period" may be variously defined as being from one year to, say, fifteen years, and the critical load per unit area which will just not appreciably strain a sample of the alloy when allowed to remain for a long period is variously referred to as "limiting creep stress," "limit of viscosity," "creep limit," etc.

If an indefinite supply of apparatus is available and one can afford to wait the results of actually stressing samples for a period of years, the subject does not present much difficulty. Heat-resisting alloys are, however, already being used regularly and the demand for them is growing; consequently, some method of test is required which will enable one to determine the "Safe-load-Temperature" curve for an alloy in a reasonable length of time, say, two months.

Dr. Rohn's Apparatus.

In the author's opinion the problem has been definitely solved by Dr. Rohn, of Hanau, and to some extent by Barr and Bardgett. In the

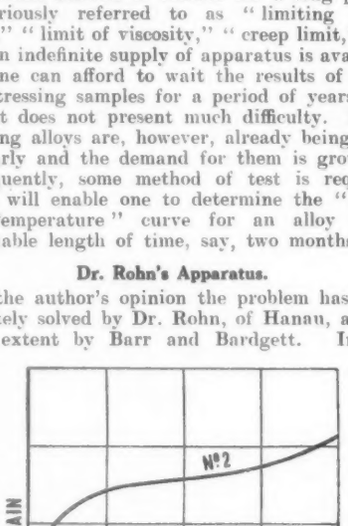

Fig. 2.—Strain-Time Curve between Elastic Limit and Maximum Stress.

Rohn apparatus[6] the test-piece, which is approximately 1 metre long, acts somewhat as an expansion pyrometer and automatically regulates the temperature of the furnace. The arrangement is such that when the desired temperature has been reached the thermal expansion of the test-piece operates an electric contact and the heating current is cut off. Thereupon the furnace and test-piece cool somewhat until the contact is again closed and the heating current renewed, when the sample heats up again and the whole cycle commences afresh. If now the test-piece, which is automatically controlling the temperature of the furnace, is loaded, the furnace temperature will not alter if the stress is below the creep stress of the test-piece. If, however, the load exceeds the creep stress and the apparatus is left to control itself, the temperature of the furnace will sink until the temperature corresponding to the creep stress under the load is reached.

When the temperature of the furnace has remained constant sufficiently long to ensure that equilibrium has been established, the load is increased and the apparatus allowed to control itself until equilibrium has been again established. Tests with this apparatus have shown that when the temperature has remained constant for not less than 50 hrs., it will remain so for a period of many weeks and, one may presume, for an indefinitely long period.

Barr and Bardgett's test[7] depends on the measurement of the diminishing rate of creep in a stressed test-piece by means of a steel weigh-bar, so that the creep of the test-piece is accompanied by a proportionate decrease in the applied stress, whilst the temperature is controlled to within ±0.5 deg. C. by means of a MacLaren thermostat located in the winding of the furnace. The extension of the weigh-bar is measured by means of an extensometer consisting of an Ames dial gauge in conjunction with a simple lever device. The weigh-bar and extensometer are accurately calibrated in a tensile-testing machine.

As a result of numerous experiments it has been found that the initial stress is approximately proportional to the decrease in stress in a given time. Hence, by plotting the decrease in stress against the initial stress, the straight line drawn through two or more points if produced cuts the initial stress axis at a certain value, representing the stress which will give no measurable decrease in stress in the period of the test. It can be shown that this must correspond to a total creep of less than 7×10^{-6} in. per inch for the period of test.

Both the above tests are really very similar. In the Rohn apparatus the load remains constant and the temperature adjusts itself, whilst in Barr and Bardgett's apparatus the temperature is maintained constant and the load automatically adjusts itself. In both tests the dimensions of the test-piece are not appreciably altered and it is possible to determine the rate of creep without any actual measurements of extension. In the Rohn apparatus the rate of creep before equilibrium is established can be calculated from the rate of fall of temperature and the coefficient of expansion of the metal under test. In the Barr and Bardgett apparatus the actual extensions can be determined from the decrease of stress. Taking into account the accuracy with which the temperature can be read in the Rohn test and the accuracy with which the Ames dial gauge can be read in Barr and Bardgett's test, it can be shown that for the values of creep stress given by either of these methods of test the total creep will be considerably less than 2×10^{-3} per cent. per hr.

It has been suggested that at elevated temperatures alloys have no true strength, and that if sufficient time be allowed they will ultimately rupture if subjected to the smallest possible load. After watching structures for long periods, and as a result of careful tests with the Rohn apparatus, the author has, however, tentatively adopted the view that at elevated temperatures below their solidus metals have an exceedingly low, but true, elastic limit, and that true creep stress is that elastic limit.

Table II.—*Thermal Conductivities of Alloys and Metals.*

C.	Cr.	Ni.	Heat conductivity (C.G.S. units).
0.3	28	Nil	0.07 (at 800° C.)
0.4	18	8	0.075 (at 800° C.)
0.6	60	20	0.08 (at 800° C.)
0.3	15	Nil	0.04 (at 100° C.)
0.3	(Mild steel)		0.07 (at 900° C.)
—	Silver		1.0 (at 100° C.)
—	Copper		0.92 (at 100° C.)

It is necessary not to lose sight of the fact that heat-resisting metals, in common with the majority of other metals, have a definite coefficient of linear expansion, and when designing plant, provision must be made for it. The actual values for the coefficient of expansion vary according to the particular composition, but it is a safe rule to assume that it is not less than 0.00002. If one assumes that in use the metal will be heated to 1,000 deg. C., provision must be made for a total linear expansion of 2 per cent., which in a structure 10 ft. long is 2.4 in.

The combined effect of thermal expansion and contraction, assisted in many cases by oxidation, leads to the total disintegration of some alloys. Alloys with a high carbon content are usually brittle and uneven heating will frequently cause

them to crack in use. In the case of some of the cast irons the increase in temperature opens up the structure to such an extent that internal oxidation takes place and castings will grow enormously without being stressed. It is also necessary not to lose sight of the fact that prolonged retention at high temperatures or slow cooling may give rise to changes of structure which render the material exceedingly brittle.

The thermal conductivity of a few typical heat-resisting alloys is given in Table II, from which it will be seen that as a class heat-resisting alloys are not good heat conductors.

In judging the importance of thermal conductivity data on metals to be used in the construction of any particular installation in which the transfer of heat is involved, Van Dusen[8] has shown that the entire thermal path must be considered as a whole. It is useless to reason offhand that a metal of high conductivity should be used to increase the heat transfer, or that a metal of low conductivity should be used to decrease heat transfer. The chances are that the possible increases or decreases so obtained will be insignificant except in very special cases.

As an example, Van Dusen mentions the simplest and most extreme case in which there is a heat flow from gas on one side of a metal sheet to gas on the other. Under any condition met with in practice, the thermal resistance of the sheet, regardless of the kind of metal of which it is composed, is utterly insignificant

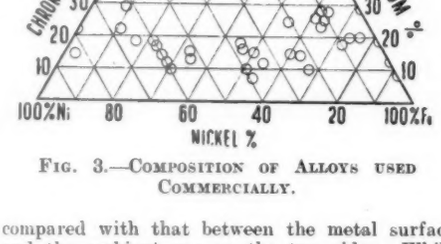

Fig. 3.—Composition of Alloys used Commercially.

compared with that between the metal surface and the ambient gas on the two sides. While the gas on one side may be many degrees hotter than that on the other, the temperature drop through the metal itself will be only a small fraction of a degree. The attempt to increase the heat transfer by an appreciable amount by using a metal of high conductivity is obviously futile. As a matter of fact, it so happens that the heat transfer might be materially reduced by using a metal sheet composed of silver, the best conducting metal known. The increase in heat transfer due to the better conducting properties of silver would be insignificant, but the decrease due to the fact that a bright silver surface has a very low emissivity for radiant heat might be considerable under certain conditions, particularly when there is no forced convection by violent agitation of the gas on the two sides.

Heat-Resisting Alloys.

Heat-resisting alloys are not recent metallurgical developments, and the majority of them have been available for a considerable number of years, but it is only comparatively recently that they have been used for engineering structures. In the early days they were used almost exclusively as electric heating elements or case-hardening boxes.

The majority of heat-resisting metals are essentially alloys of nickel and/or chromium and iron. They also contain various small percentages of carbon, tungsten, copper, molybdenun, etc. In Fig. 3 the proportions of nickel, chromium and iron of some of the alloys which are already being produced in quantities are indicated by means of circles, and the actual analyses of a number of them are given in Table III.

The scaling temperatures in air of eight different alloys are given in Table IV. In the presence of sulphur the resistance to attack is more or less inversely proportional to the amount of nickel present, and the greatest resistance is exhibited by nickel-free alloys containing approximately 28 per cent. of chromium. The addition of aluminium to a nickel-chromium alloy considerably increases its resistance to sulphur attack, but it is then difficult, and consequently expensive, to produce. It is interesting to note, however, that if nickel-chromium alloys are treated with aluminium, they become completely resistant to sulphur attack.[9]

Carbon does not affect the resistance to scaling to an appreciable extent, but does lower the melting-point. Tungsten slightly increases the resistance to sulphur attack, but has no appreciable effect upon the resistance to scaling in oxidising atmospheres free from sulphur.

At elevated temperatures heat-resisting alloys have a very much greater strength than ordinary structural steels, which are, in general, remarkably ductile at 700 deg. C. and upwards. Whilst nickel and/or chromium are essential constituents of the majority of heat-resisting metals, carbon and tungsten play a very important part in producing a metal characterised by good tensile properties at elevated temperatures. Both elements must, however, be used with discretion; 1 per cent. of carbon may be present in alloys which are only required in the form of castings, but, if rolled sections are required, the carbon must be reduced. It should not, however, be less than 0.3 per cent. if the alloys are required for a part that has to withstand stress.

Table III.—*Composition of Heat Resisting Alloys.*

No.	C.	Ni.	Cr.	Si.	Mn.	W.	Cu.	Al.	Fe.
9	0.63	64.9	19.9	1.80	1.1	Nil	Nil	Nil	Balance
10	1.37	40.0	8.5	0.49	1.9	,,	5.5	,,	,,
11	0.65	60.0	20.5	1.0	0.95	3.2	Nil	,,	,,
12	0.50	67	20	1.75	1.32	Nil	,,	,,	,,
13	0.40	40	17	1.0	1.0	,,	,,	,,	,,
14	0.50	38	18	2.0	1.12	,,	,,	,,	,,
15	0.50	36	16	1.50	0.70	,,	,,	,,	,,
16	0.45	22	14	0.80	0.90	,,	,,	,,	,,
17	0.20	17.5	25	0.50	1.12	,,	,,	,,	,,
18	0.40	8.0	18	0.75	0.5	,,	,,	,,	,,
19	0.20	25.0	17.0	2.5	—	,,	,,	,,	,,
20	0.45	14.0	14.0	0.67	0.79	2.0	,,	,,	,,
21	0.3	Nil	28.0	0.7	0.4	Nil	,,	,,	,,
22	0.8	2.0	28.0	0.8	2.0	,,	,,	,,	,,
23	0.1	61.0	15.0	—	4.0	,,	,,	10.0	,,
24	0.3	0.5	18.0	0.2	0.4	,,	,,	Nil	,,
25	0.6	66.0	19.0	1.0	1.8	,,	,,	7.0	,,
26	0.45	26.0	14.0	1.25	1.25	3.5	,,	Nil	,,
27	0.35	7.5	20.0	1.40	0.6	4.0	,,	,,	,,
28	1.50	30.0	30.0	1.0	—	4.0	,,	,,	,,

Table IV.—*Scaling Temperatures of Various Alloys.*

	C.	Ni.	Cr.	Scaling temperature.
1	0.9	66	21	1,200° C –1,250° C
2	0.8	60	20	1,200° C.–1,250° C.
3	1.4	30	30	1,050° C.–1,100° C.
4	0.8	Nil	28	1,050° C.–1,100° C.
5	0.7	57	15	1,150° C.–1,200° C.
6	0.5	21	14	1,050° C.–1,100° C.
7	0.3	Nil	28	1,050° C.–1,100° C.
8	0.2	8	18	900° C.– 950° C.

Influence of Carbon.

Increase of the carbon content renders the alloys more brittle and more liable to crack due to uneven heating. A short time ago a considerable amount of information[10] about the great strength at elevated temperatures of alloy No. 28 was published. Unfortunately, it is of very little use in industry because of its extreme brittleness. It can only be used under conditions where there is no risk of uneven heating.

Fig. 4 shows the Creep-stress-temperature curve of alloy No. 20 (rolled material) as determined by the Rohn apparatus. If rolled or forged material is used it is not necessary to use a high factor of safety, and designers usually use a factor of about 2. If cast material is used the author considers that a factor of safety of at least 5 should be introduced. When deciding on the factor of safety to use it is necessary to consider not only the possibility of defects being present in the castings, but also the fact that the structure may be over-heated at some time during its life. Alloy No. 6 is not a particularly high-grade heat-resisting alloy, and alloys containing 60 per cent. nickel and 20 per cent. chromium suitably alloyed with carbon, tungsten, etc., are considerably stronger and have a creep stress of 400 lbs. per sq. in. at 1,000 deg. C.

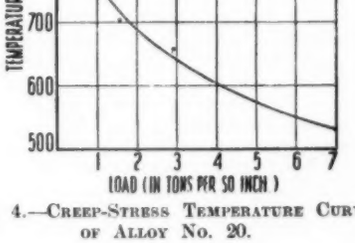

Fig. 4.—Creep-Stress Temperature Curve of Alloy No. 20.

BIBLIOGRAPHY.

1 Hatfield, "Heat-Resisting Steels," J. Iron and Steel Inst., Vol. 115, 483, 1927.
2 Kayser, "Heat and Acid-Resisting Alloys (Ni-Cr-Fe)," Trans Faraday Soc., Vol. 19, 184, 1923.
3 Dickinson, "Some Experiments on the Flow of Steels at a Low Red Heat, with a note on the Scaling of Heated Steels," J. Iron and Steel Inst., Vol. 106, 103, 1922.
4 Hatfield, "Heat-Resisting Steels. Part 2.—Mechanical Properties," J. Iron and Steel Inst., Vol. 117, 573, 1928.
5 Chevenard, "The Mechanical Properties of Metals at Elevated Temperatures." Symposium on Effect of Temperature on the Properties of Metals. A.S.M.E. and A.S.T.M., June, 1931.
6 Rohn, "Die Bestimmung der Kriechgrenze." Sonderabdruck aus der Festschrift zum 70. Geburtstage von Dr. phil. Dr. ing. e.h. W. Heraeus.
7 Barr and Bardgett, "An Accelerated Test for the Determination of the Limiting Creep Stress of Metals," Inst. Mech. E., Advance copy, February, 1932.
8 Van Dusen, "Note on Application of Data on the Thermal Conductivity of Metals." Symposium on Effect of Temperature on the Properties of Metals. A.S.M.E. and A.S.T.M., June, 1931.
9 Kayser, "Surface Treatment of Metals with Aluminium," The Metallurgist. Supplement to "The Engineer," March 27, 1925.
10 Jenkins and others, "Some Alloys for Use at High Temperatures," J. Iron and Steel Inst., Vol. 121, 237, 1930.
11 Robiette, Discussion on "Growth and Scaling of Cast Iron," by Norbury and Morgan, J. Iron and Steel Inst., Vol. 123, 413, 1931

(To be concluded.)

Cracks in Ingots.—Cracks in ingots have been traced by a steelmaker in the Chicago district to tar-coated moulds. This conclusion is based on tests made by spraying the moulds alternately with tar and with graphite and using the same complement of moulds on the same heat of steel.—"Steel."

Some Observations on the Character of Cast Iron.

This Paper, which was printed in our last issue, created much interest, both within the meeting and in the foundry industry generally. Below Mr. Vivian, the author, replies to two written contributions.

In reply to Mr. C. Howell Kain, Mr. Vivian wrote:—Mr. Kain's opening remarks provide a strong measure of support for the opinion expressed that melting and cooling conditions should be included in specifications.

It is agreed that small bars machined "off-centre" show greater strength than bars from the centre of a casting. The extent of the difference is the point of importance in casting design. The metal comprised within a ½-in. dia. cylinder along the centre is only 6¼ per cent. of the total metal in 2-in. dia. parallel-sided bar. If the metal at the centre had no tensile strength at all, it might not seriously decrease the breaking strength of the bar, and this point is worthy of particular attention when assessing the ill-effects of "thickness."

In analysing Messrs. Adamson & Bell's results referred to in the Paper, the author took the "as-cast" skin to be 50 per cent. stronger to a depth of $\frac{1}{16}$ in. than the metal inside, and assumed the metal inside to be of uniform strength. The maximum size of bar was 2.2 in. dia. In only one out of the thirteen different grades tested did this rough rule fail to show consistent results. In other words, "openness of structure" was only serious in one case.

Regarding reinforcement, Mr. Kain summarises the practical difficulties. There are also difficulties of accurate stress computation in the case of a composite material such as a reinforced cast-iron beam would be. It is thought that the latter difficulties are not insuperable, but the question arises whether the serious practical difficulties are worth overcoming by exhaustive research. The golden prize of successful research would be the use of an ordinary grey iron for a large variety of purposes, structures, machines, etc., from which it is at present shut out by reason of its lack of ductility. Provide it with ductility by alloy additions, and the remarkable property of a quite ordinary iron to resist a compressive stress of 30 tons per sq. in. without serious deformation may be completely lost, while the price is greatly enhanced. The answer to the question of reinforcement of cast iron lies, in the author's opinion, in the future.

Transverse test-bars machined to a size of 2 in. by 1 in. by 42 in. were suggested by the author as suitable for laboratory testing. It is admitted that this needs qualification. If standardisation of charge, melting conditions and rate of cooling were specified, then laboratory tests on 2-in. by 1-in. by 42-in. bars would provide more accurate information regarding the irons produced to such specification than tests on round bars. For ordinary routine check testing such accuracy would not be necessary. It is suggested that piston-ring testing might prove admirable for many purposes.

In thanking Mr. Kain for his kind remarks, the author would strongly support his concluding statement that many of the doubts about cast iron will vanish when uniformity and soundness can be guaranteed.

Mr. Pearce's Views Examined.

In reply to Mr. J. G. Pearce, the author wrote:—Regarding Mr. Pearce's evidence that a variety of irons have shown a straight stress-strain curve for the elastic component in bending, the theoretical tensile stress-elastic strain and the load-elastic deflection curves of the B.C.I.R.A. results should be compared. It will be seen that the considerable curvature of the former is not reproduced in the latter. The load-elastic deflection line is both, according to the author's theory and in fact, almost a straight line. Mr. C. Howell Kain also raised a query regarding the 2-in. by 1-in. bar, and a reply on this point is made thereunder.

With regard to shear effect, six values of tensile strength are given in the May, 1932, B.C.I.R.A. test results. These ranged from 12.80 to 11.85 tons per sq. in. and were obtained on standard 1.2-in. dia. bars. For the tensile stress-elongation measurements a 1.2-in. bar was reduced to 0.564 in. dia. instead of the standard 0.798 in. dia. The tensile strength was found to be 13.8 tons per sq. in. on this bar instead of a maximum of 12.8 tons per sq. in. on the standard 1.2-in. bar. These tests provide, in the author's opinion, the clearest possible evidence of shear effect in the standard 1.2-in. dia. bar.

The fact that, in the case of the 16- to 18-ton iron reported in B.C.I.R.A. Bulletin, April, 1932, and further tested as described in Mr. Pearce's observations under review, no reduction in tensile strength, with a very short grip length was observed, is not necessarily evidence of the absence of shear effect in the standard 1.2-in. dia. bar. These tests prove, in the author's opinion, that the 16- to 18-ton iron possessed sufficient plasticity to eliminate the non-uniformity of stress which would otherwise have been produced by the shear effect. The 13- to 14-ton iron, on the other hand, did not possess sufficient plasticity for the purpose.

In the case of a variety of irons up to 2.2 in. thickness, Messrs. Adamsons & Bell's test results, referred to in the Paper, show that with one exception the difference in thickness as between 2.2-in dia. and 0.875-in. dia. bars does not produce an appreciable difference in tensile breaking strength. The exception was the iron described under Set F which need not necessarily be used for engineering purposes. Above 2.2 in. thickness it may be that openness of structure contributes materially to reduction in strength, but it is not clear that sections thicker than about 2 in. need normally be used for a variety of engineering purposes.

The author desires to reiterate his thanks to Mr. Pearce and the Council of the British Cast Iron Research Association for carrying out the comprehensive series of tests referred to in the Paper.

DISCUSSION.

Mr. G. S. Bell (Lincoln) described the Paper as one which was, in its intents and purposes, extremely revolutionary. The theories put forward in it were extremely sound; they were based on tests, and were capable of being proved to that extent. Whilst not wishing to run the risk of starting a hare along a wrong path, Mr. Bell suggested that the meeting might with advantage discuss how the theories accorded with some of the ideas of practical foundrymen from the point of view of the structure of the metal. Referring to the tests with which he had been concerned, and which had been mentioned in the Paper, he said that they numbered thousands; he and his co-workers had examined them almost as thoroughly as had Mr. Vivian, and they had found most striking evidence of the correctness of Mr. Vivian's theories. Mr. Vivian was indeed a pioneer. His Paper was a very brilliant exposition, not only mathematically, but metallurgically; it was a good deal ahead of its time, but it would be approved eventually.

Perfect Test Pieces.

Mr. V. C. Faulkner (Past-President of the Institute) recalled that in his university days he had always considered testing to be about the driest subject that one could tackle, and it had always been a bore to him personally; but after hearing Mr. Vivian's very lucid Paper one felt one must take a new interest in it, because of the revolutionary theory put forward. He wondered if it would be a help to Mr. Vivian if the foundrymen gave him perfect castings, because they *could* provide him with perfect castings to test. When criticising the recent developments of the British Cast Iron Research Association, he (Mr. Faulkner) had suggested that the Association might work on perfect test pieces; perfect test pieces would be derived from perfect castings, and perfect castings would be made by the centrifugal process. Could one go further, and ask the engineering profession whether, if one installed a small centrifugal casting machine, they would accept test so derived from perfect casting as representing the metal turned out from that particular foundry?

Again, he asked how Mr. Vivian viewed the type of test involving the testing in shear of small test pieces trepanned from castings. Much time and energy had been expended on such tests during the last five or six years, and very strenuous efforts had been made by Continental experts to make their standard.

Mr. Faulkner added that he asked these questions because foundrymen realised that, owing to the metallurgical conditions, each size of test piece had a different pouring rate and a different structure. Even people who were very familiar with cast iron did not really appreciate the full effect.

Finally, he expressed indebtedness to Mr. Vivian for having selected the London Branch of the Institute as the medium through which to give publicity to his revolutionary and very interesting theory on the testing of cast iron.

Author's Reply.

Mr. Vivian expressed his indebtedness for the kind manner in which his Paper had been received, and thanked Mr. Bell particularly for the assistance he had given in the way of tests.

Dealing with Mr. Faulkner's question as to whether engineers would be prepared to accept a perfect casting as representative of the ordinary cast iron turned out by a particular foundry, he said he understood that in the ordinary way the foundry would produce castings and for the purposes of test would produce perfect test-pieces. Speaking personally—and he believed he could speak also for other engineers—the answer to the question would be "No." The whole object of the Paper was to endeavour to show that ordinary castings were capable of simple interpretation. The basis of the theory upon which he had been working was that cast iron was not really an uncertain material; that if, as he believed could be done, the tensile and the transverse strengths could be correlated, the way was open for the extended use of cast iron in more directions than was permissible so far. The reason why a constructional engineer would fight shy of cast iron was the feeling that one could not be quite sure of it. Mr. Vivian recalled that only two or three years ago, when he had asked a professor at his own college to run some tests for him in cast iron, the reply had been that when dealing with cast iron one did not know where one was. On the part of men who did not understand cast iron there was a feeling of uncertainty with regard to it, but he considered that that uncertainty was not justified, and he had endeavoured to show in the Paper that the transverse and tensile strengths of cast iron were just the same. Engineers did not want tests on perfect castings in the sense mentioned by Mr. Faulkner; they wanted simple transverse and tensile tests, and from those tests one would be able, if the theory could be established, to design in cast iron with confidence, and with as much certainty as in steel.

As to the size of test-bars, he said that if he were asked to design a size of test-bar for ordinary grey-iron castings up to, say, 1½ in. dia., he would design one having a test-diameter smaller than usual relative to its length and grip diameter. He illustrated such a test-bar. As a basis for discussion he suggested the dimensions for a standard 1.2-in. bar—applicable for

(*Concluded on page* 269.)

British Cast Iron Research Association.

ELEVENTH ANNUAL REPORT.

At the annual meeting of the Association held at the Institution of Mechanical Engineers yesterday, the annual report was presented, of which the following is an abstract:—

The year 1931-32, the first of the second decade of the Association's existence, has been an eventful one in its history. At the opening of the year the new conditions under which grant was to be received from the Department of Scientific and Industrial Research came into operation. The steady deepening of the depression in the industry since these conditions were settled in 1929 made the increased financial response from the industry, which was an essential part of the scheme, very problematical. The situation called for the expenditure of much consideration by the Council and Director, and the course of action taken is referred to more fully below. Early in January two of the laboratories, the chemical and physical, were damaged by fire and the changes following this, detailed below, culminated in the opening of new laboratories by Lord Rutherford of Nelson on July 6.

The Council unanimously re-elected as chairman Mr. H. B. Weeks, F.I.C., and as vice-chairmen Mr. J. T. Goodwin, M.B.E., and Mr. F. J. Cook, M.I.Mech.E. During the year six meetings of the Council have been held with an average attendance of 16.

Research Committee.

Mr. W. H. Whitehouse, A.M.Inst.C.E., M.I.Mech.E., was unanimously re-elected chairman of the Research Committee and during the year five meetings have been held with an average attendance of 13. The Committee with the assistance of the Research Sub-Committees has made a detailed examination of the research and development programme and formulated the new programme to the report. It is not, of course, anticipated that the programme as a whole can be completed in the twelve months, but it is prepared with a view to taking the greatest possible advantage of the common ground between the various sections, to the dovetailing of investigations, and also to the maintenance of full working pressure in other directions while one piece of work may be temporarily delayed for material or apparatus. The extent to which the Association co-operates with members in arranging experimental melts and the delay sometimes consequent on working on an industrial scale, makes this particularly desirable

The whole of the sub-committees of the Research Committee, which consists of specialists who supervise the separate branches of the research programme, have continued as given in the last report. Six sub-committees refer to particular types of product in which the industry is interested, as follow:—Grey-iron sub-committee; nickel and alloy cast iron sub-committee; malleable cast iron sub-committee; foundry pig-iron sub-committee; light castings sub-committee and white and chilled iron sub-committee.

Matters of common interest affecting all sections of the trade are dealt with by three other sub-committees:—Sands and refractories sub-committee; tests and specifications sub-committee and cupola sub-committee.

Panels of the sub-committees are formed for special purposes as and when desirable. During the year 17 sub-committee meetings have been held with an average attendance of nine. The progress made on the research work is briefly summarised.

Grey Iron Sub-Committee.

For some years past the Association has studied the effect of the various elements present in cast iron. The general effect of each element, acting individually, usually present in ordinary cast iron—silicon, phosphorus, manganese, sulphur—has been known for some time, but the effect of two or more elements acting conjointly is less understood. Furthermore, it is not generally appreciated that each individual element affects the metal in various ways. Attention in the past has been given principally to the effect of each element assisting or retarding graphitisation, the rate of which in a given section determines the extent to which the metal is soft or hard. In addition, however, to the hardness determined by the amount of total carbon which is converted to graphite, it is necessary to consider the intrinsic hardness of the solid solution of each element entering into solution with the iron, or alternatively, the intrinsic hardness of that part of the structure which may form carbide with the iron in addition to the iron itself. Silicon and nickel are illustrations of the former action and manganese and chromium of the latter. Reactions between individual elements also require consideration, as manganese-sulphur and manganese-silicon-sulphur. Again some elements raise the critical point, known as the pearlite change point, at which carbon begins to go into solution. This point is of great importance in a variety of applications. Effects of components of the structure on mechanical properties also require consideration. Thus phosphorus, generally considered to be a weakening element in heat-resisting irons on account of the low melting point of the phosphide eutectic, has been demonstrated by the Association to contribute to the rigidity of phosphorus-rich irons, under heat, up to the point at which the phosphide eutectic becomes plastic, at which collapse of the metal may be expected. A good deal of work has been done, therefore, during the past few years on the joint action of the elements present in normal irons. Some results have been made available to members in previous years, such as the joint effect of manganese and sulphur, and of carbon and silicon. During the year further reports have been prepared on the joint effect of manganese and silicon and work has been completed and reports are in preparation on the joint effects of sulphur and silicon, and phosphorus and silicon, silicon itself being regarded as the indispensable constituent in commercial cast irons, the manipulation of which is the main means of control of properties at present open to the founder. It has been evident, however, for some time that the ordinary theory of silicon control, the foundations of which were laid in 1885, requires modification, and the Association has been able to make a notable step towards clearing up anomalies repeatedly found both in the laboratory and in practice, by work on the effect of melting conditions, by which it has been demonstrated that, quite irrespective of composition, the structure and hence the properties of cast iron can be very materially modified by controlling and manipulating the conditions under which the metal is melted. This work led naturally to the study of superheating, the effects of which were found under certain conditions to be undesirable in modern high-quality material. The constant improvement proceding in methods of melting, furnace practice, and the raising of melting temperatures necessitated some means whereby this disadvantage could be offset and this resulted in the development of what the Association termed the "inoculation process." Here germs of graphite, necessary as crystallisation centres for fine-flake graphite, are artificially furnished, in cases where the conditions of melting are such as to yield a material without graphitic germs or such as to result in germs present going into solution during melting. Establishment of the inoculation process on a sound basis is one of the main problems at present before the Association, and during the year a report has been prepared on the effect of superheating and inoculating, dealing with a variety of inoculating materials, the effect of variations in the quality of the inoculation added, the effect of holding metal in the ladle prior to inoculation, and the effect of holding metal in the ladle prior to casting.

At the spring meeting of the Iron and Steel Institute a section of the fourth report of the Heterogeneity Committee on Steel Ingots referred to the thermal properties of irons used in steel-ingot moulds. One part of this, dealing with general thermal and physical properties, was carried out in the laboratories and presented by the Association, and for the other section dealing with the thermal conductivity of ingot-mould irons, the Association was able to obtain the co-operation of Dr. J. W. Donaldson, who has had special experience in this field. The investigation on the strength of cast iron in relation to size and the correlation of mechanical tests has also been actively continued and approaches completion.

Nickel and Alloy Cast- Iron Sub-Committee.

During the past few years considerable development has taken place in alloy cast irons, particularly in the addition of nickel and chromium. Vanadium, titanium, molybdenum, copper and aluminium are also commonly-found constituents in many high-quality materials and in parallel with the work mentioned above on grey iron, similar work has been done on nickel and chromium. Reports have been presented on nickel-silicon cast irons, on chromium-silicon cast irons, and towards the end of the year on the conjoint influence of three elements, chromium-nickel-silicon and nickel-manganese-silicon. While ordinary cast irons are predominantly pearlitic in structure, by the use of suitable alloying elements, martensitic and austenitic structures can be obtained and the special properties of these irons are now being rapidly recognised in particular applications.

The study of the various effects of elements in cast iron over the range normally present in ordinary material is difficult on account of the fact that some effects are mutually antagonistic. In view of this it was found desirable to study the effects of elements over a much wider range than has hitherto been usual in investigating cast iron, so that a tendency detected in dealing with small percentages could be confirmed by ascertaining the effect of larger additions. This has also facilitated the study of the martensitic and austenitic structures.

The Nickel and Alloy Cast-Iron Sub-Committee also deals with the special heat-resisting irons which were referred to in the last report, particularly Silal and Nicrosilal. The Association now has six members making Silal under licence, the material being covered by British Patent No. 323,076. The Silal licensees are as follows—Davy Bros, Limited, Sheffield; The Horsehay Company, Limited, Wellington, Shropshire; Knottingley Foundry Company, Knottingley, Yorks; S. Russell & Sons, Limited, Leicester; The Sheepbridge Stokes Centrifugal Castings Company, Limited, Chesterfield; and Smith, Patterson & Company, Limited, Blaydon-on-Tyne.

Other licences are being negotiated. Four of the above members are producing Nicrosilal under the Association's British Patent No. 378,508. Some results of commercial operation are given in the president's address.

Nicrosilal is an iron of austenitic structure, relatively corrosion-resisting and non-magnetic, but extremely resistant to growth and scaling, more so than any cast iron previously produced. It can be made extremely soft—Brinell hardness about 130—or by slight modification of the composition, in any required grade of hardness up to and exceeding the limit of machinability. It has a measure of ductility in the cold state, about 3 per cent. on 2 in., for the soft variety, and retains its mechanical properties to an un-

usual extent at elevated temperatures. The tensile strength in the cold varies from about 18 to 25 tons per sq. in. Its thermal conductivity is slightly less than that of ordinary grey iron and the thermal expansion slightly higher. It it at present made almost entirely in the crucible, although experimental cupola melts have been tried, and it has been applied to various industrial applications such as furnace castings, glass-bottle moulds, ingot moulds, combustion heads, etc. It is virtually a Silal with the addition of nickel and chromium. The machinable grades take a very fine mirror finish. In a series of tests on bars heated in a muffle to 1,000 deg. C., which caused mild steel to scale excessively and a 1.7 per cent. silicon engineering cast iron to grow 16 per cent. in volume, and Silal to grow from 2.7 per cent. to 5.6 per cent., a soft Nicrosilal was practically untarnished and showed a growth of 1.3 per cent. only, this figure being roughly one-fourth of the thermal expansion of the metal at the temperature given.

A further interesting development during the year has been the production of another austenitic iron by means of manganese and aluminium additions.

Malleable Cast-Iron Sub-Committee.

Following the investigation on the most appropriate shape and size of malleable test-bar and the desirability of varying the size of bar to suit the casting, arrangements have been made to confirm in commercial practice the results obtained, as a preliminary to making recommendations for use in specifications. During the year a meeting of members making malleable iron was held in Birmingham for the purpose of discussing certain difficulties in the production of white-heart malleable, particularly in the cupola, and further developments are expected as a consequence of this meeting.

Pig-Iron Sub-Committee.

The development of the purchase of pig and refined irons to analysis resulted in the preparation by the foundry pig-iron sub-committee of a list of tolerances for various elements, within range of which the specified figure would be deemed satisfactory. These tolerances have been circulated to members as a research report for trial, with a view to general use if experience proves them to be satisfactory. As a consequence of a series of visits made by the senior metallurgist to blast furnaces, a report was prepared on factors affecting the fracture of pig-iron, from which it is concluded that the total carbon and silicon contents in a pig may vary and yet yield the same fracture, provided the silicon rises as the total carbon falls and *vice versa*. The programme does not contain specific proposals for research on pig-iron, but the interests of the pig-iron sub-committee in connection with the influence of composition, superheating and inoculation are being borne in mind in the work proceeding on grey iron.

White and Chilled Iron Sub-Committee

This sub-committee has been comparatively recently formed, and work on white and chilled iron does not form any specific part of the programme, although standard chill tests are cast in connection with all experimental melts made. Work is also being done by individual members of the sub-committee in their own works as a preliminary to the formulation of specific proposals.

Sands and Refractories Sub-Committee.

This investigation is proceeding as previously at the University of Sheffield under the supervision of Mr. W. J. Rees, M.Sc., by Dr. J. G. A. Skerl, and greatly improved accommodation has recently become available for the Refractories Department. The demand among members for the services of the investigator to apply the results on moulding sands has retarded the progress of the research work on core sands and refractories, but the first report on core sands is approaching completion. Some forty binders and binder mixtures have been examined. Some practical trials of cupola bricks, which gave much superior results to ordinary linings on laboratory tests, have not been successful, mainly on account of the severe working conditions of the cupola.

Tests and Specifications Sub-Committee.

This sub-committee does not deal with any part of the research programme, but is concerned with the standardisation of methods of testing, with specifications and related matters. The preparation of the re-issue of the report on recommended methods of analysis has proved a large undertaking, for the sub-committee decided to include methods relating to the special elements now frequently found in commercial irons and the report will be issued during the current year.

Cupola Sub-Committee.

The main work accomplished during the year has been the industrial development of the balanced blast cupola. During the first year following its development five cupolas were installed, and during the following year ten. The number now under construction or actually installed is twenty-three, with an aggregate capacity of 120 tons per hour. The first application has been made to the melting of malleable cast iron with considerable success. In a particular case, detailed figures of which have been furnished to the Association, a 27-in. cupola put into operation furnished the total cost of conversion out of economies in less than seven weeks, and a 26-in. cupola in less than ten weeks, and the total savings are of the order of £1,500 per annum. The scrap reduction and other advantages resulting from the conversion are regarded as of even greater value, but are difficult to assess precisely in figures.

During the year arrangements have been made for the leading cupola manufacturers in the country to make this cupola to the requirements of members, and the following are licensed to manufacture under the Association's British Patent No. 333,322:—Alldays & Onions, Limited, Birmingham; Constructional Engineering Company, Limited, Birmingham; Geo. Green & Company, Keighley; The Horsehay Company, Limited, Wellington, Shropshire; J. W. Jackman & Company, Limited, Manchester; and Pneulec, Limited, Smethwick.

Development Department.

The work of the Development Department has been referred to above at appropriate points and continues to play an increasingly important part in the organisation. In addition, during the year some 500 inquiries were received from members and dealt with, and on them about 450 reports were issued. During the past six months a noticeable increase has occurred in the number of inquiries received, and during the year the number of visits paid by the staff to members has been about 450. Of these, 57 visits were paid by the sands investigator and 223 by the superintendent of the Scottish Laboratory at Falkirk, the remainder being by the headquarter's staff.

Since the opening of the laboratory extensions the melting and casting work has been arranged as a separate small department on the same footing as the remaining sections. The laboratories, as in previous years, have contributed to the progress of both research and development work. During the year in the chemical laboratory approximately 2,000 estimations were made, and in the metallographical laboratory approximately 630 micro-examinations were carried out, about 70 of which were recorded photographically in permanent form. In the mechanical testing laboratory 875 mechanical tests—tensile, transverse, compression, impact—were made.

Annual Meeting.

The annual general meeting was held in London on November 11, 1931, with Sir Harold Hartley, C.B.E., M.C., F.R.S., President of the Association, in the chair. After the report and accounts had been approved, following a brief outline by the chairman of the work done. Sir Harold Hartley was unanimously re-elected President, and Major F. A. Freeth, O.B.E., F.R.S., Mr. Charles Retallack, Engineer Vice-Admiral Sir R. W. Skelton, K.C.B., C.B.E., D.S.O., and Mr. Oliver Stubbs, M.I.Mech.E., were elected Vice-Presidents. The Council deplores the loss during the year of two Vice-Presidents, Mr. Charles Retallack, for very many years managing director of John Harper & Company, Limited, Willenhall, and Mr. Oliver Stubbs, of Joseph Stubbs, Limited, Manchester. Both these gentlemen were members of the original Provisional Committee which preceded the Association, and took a keen and active interest in our work. Their loss will be severely felt in the industry. Another severe loss was caused by the death at a very early age of Mr. H. C. Dews, member of Council.

Staff.

Mr. F. K. Neath, B.Sc., who had become well known as a member of the staff of the Association since he joined it in 1923, left during the year to take up an industrial position, and the Council wishes him every success for the future. Mr. L. W. Bolton and Mr. C. Rowley have been awarded Carnegie Scholarships by the Iron and Steel Institute. Among the junior staff Mr. A. A. Timmins was awarded a bronze medal for a Paper to the Birmingham Metallurgical Society, and Mr. L. Lee, who works at Sheffield, won a prize as the best all-round second-year student at Sheffield University.

Laboratory Extensions.

Reference has been made previously to damage to two of the laboratories of the Association. The Council had for some time been conscious of the shortcomings of the accommodation and equipment in view of the continued growth of the Association's work, but the usual difficulties of finance both with respect to extending the accommodation and to providing apparatus and equipment had prevented the necessary action being taken. The necessity for replacing supplies and equipment for the two laboratories mentioned caused the Council to consider the desirability of finding more suitable accommodation, and it was decided to move the whole of the offices and laboratories to adjacent premises offering a much more favourable location. The original premises had been in occupation since 1926, when offices and laboratories were first opened under one roof. The new premises cover about 4,500 sq. ft., mainly on the ground floor, and offer a 60 per cent. increase in the floor area over that previously available and an increased proportion of the space devoted to research and development. The lay-out of the laboratories and description of the equipment was given in The Foundry Trade Journal for July 14 and August 4, 1932. The Council desires to record its appreciation of the assistance rendered by Mr. F. J. Cook, M.I.Mech.E., in connection with the arrangement of the laboratories and also to Mr. J. H. Mees, of Bailey, Pegg & Company, Limited, and Dr. F. Johnson, of the Birmingham Central Technical College, for assistance while the laboratory extensions were in progress.

Finance.

As explained in the last report, the Association had in 1929 made a contract with the Department of Scientific and Industrial Research replacing the one under which the Association had, since its inception, received £ for £ grant on industrial subscriptions. It should be stated that it is the constant endeavour of the Department in dealing with all research associations to adjust its grant to encourage the industry concerned to furnish annually the minimum amount required to maintain their Association in a reasonably efficient condition. The original plan provided for the associations becoming entirely self-supporting at the end of five years. The new conditions in respect of the British Cast Iron Research Association provided for a so-called datum line of £5,000, subscriptions over

and above this total only qualifying for £ for £ grant. To maintain the income of £10,000 per year previously reached and expended, it therefore became necessary to secure from the industry at least £7,500 per annum and a subscription income of £10,000 per annum would have yielded a total income of £15,000 per annum. The latter figure is the one at which the Council aims, in order to make the Association with its present staff reasonably equipped to meet the demands made on it by members. Two factors combined to make the contract impossible to achieve. The growing depression in the industry made it clear that many members could not meet the necessary increases in subscription which were proposed by the Council and also precluded many prospective members from giving their support. Secondly, the national financial crisis made it necessary for the Department itself to economise in every possible way. It soon became evident that the maximum income which the Association could expect from the trade would fall short of the minimum of £7,500. In fact, for the year it actually reached £6,278. The Council, therefore, was faced with the alternatives of a serious reduction in the staff and activities of the Association or an appeal to the Department to modify the arrangement. The latter course was decided upon and ultimately the Advisory Council to the Department met a deputation from the B.C.I.R.A. Council, led by the President, Sir Harold Hartley. The President stated the Association's case in a most able and convincing way and as a consequence the Department finally accepted the recommendations of the Advisory Council to offer the Association a maximum grant of £3,000 subject to the industry raising £6,250 for the year now under review, and a similar grant for the year 1932-33, subject to the industry raising £6,500. It will be seen that the Association was able, with a small margin, to qualify for the maximum grant and for the current year is faced with the necessity of obtaining a further increase in income of £250 to qualify for the same grant again. As from July 1, 1933, the conditions which should have come into operation on July 1, 1931, will be reimposed. It will, therefore, be evident that by the Department's action the Association has been able to avoid a calamitous reduction in its activities during the depressed period. At the same time it is essential that a much wider measure of support must be obtained if the work is to continue beyond the current financial year. Such statistics as the industry has available offer convincing testimony to the extent of the depression, but it is hoped that conditions are now improving.

The balance sheet shows a reduction in grant for the year of £1,963 and a reduction in total income of £621, the balance having been made good by increased subscriptions and new members. Expenses have been reduced, partly by reductions in working expenses, but mainly by an all-round cut in salaries proposed and voluntarily accepted by the staff. The excess of expenditure over income is represented by non-recurring items. All these pronouncements emphasise even in acute industrial depression the vital importance of continuing industrial research as contributing to our industrial recovery and our future industrial supremacy.

Membership.

At the close of the year the subscribing membership in all classes was 310 and the number of ordinary and trade members is 242, the reduction from the previous year showing the combined effect of trade depression and increased subscription rate.

Relations with Other Bodies.

The Association is indebted to a number of distinguished scientists who assist its work from time to time, in particular to Prof. Sir Harold Carpenter, F.R.S., Dr. C. H. Desch, F.R.S., Principal C. A. Edwards, D.Sc., Prof. D. Hanson, D.Sc., Dr. W. H. Hatfield, Sir William Larke, K.B.E., Mr. W. J. Rees, M.Sc., Dr. W. Rosenhain, F.R.S., Emeritus Prof. T. Turner. Dr. J. H. Andrew, honorary member, has succeeded Dr. C. H. Desch at the University of Sheffield. Dr. R. S. Hutton has been appointed the first Goldsmith's Professor of Metallurgy at the University of Cambridge.

The relations of the Association with the Institute of British Foundrymen continue to be close and during the year the Association has appointed representatives on the Technical Committee and various sub-committees set up. Discussions have also taken place on the function and work of the Institute of British Foundrymen Technical Committee. It may be added that the Director is for the current year President of the Birmingham, Coventry and West Midlands Branch of the Institute. As in previous years, an official visit was paid to the British Industries Fair in February, the Chairman of Council responding on behalf of the Association to the welcome and luncheon offered by the Fair Committee.

Conclusion.

The Association is greatly indebted to the Advisory Council of the Department of Scientific and Industrial Research for its sympathetic consideration of the difficulties experienced in reaching the original subscription datum, and emphasises to the industry that in July, 1933, the breathing space of two years allowed by the Department will expire. Unless action is taken in the meantime, the crisis which existed in July, 1931, will then arise again, and in this connection the attention of all manufacturers' associations in the industry is drawn to the remarks of Lord Rutherford at the meeting held in Birmingham on July 6. The prospects of the industry have in the last few months undergone a material change on account of the action of the Import Duties Advisory Committee, and Lord Rutherford suggested that the public, and hence the Government, would expect any industry which was protected by a tariff to be thoroughly aware of the need for reorganisation and for scientific research, and, bearing this in mind, the necessity for more generous support to its Research Association by the industry cannot be too strongly emphasised.

The Report is signed by Mr. H. B. Weeks, Chairman of Council, and Mr. J. G. Pearce, Director and Secretary.

Some Observations on the Character of Cast Iron.

(*Concluded from page* 266.)

thicknesses up to 1.2 in.—these dimensions having been prompted by his researches into the tensile strengths of cast iron. The diameter at the end section of the bar would be 1.2 in. and its length 1 in.; the next section of the bar would be about 1 in. dia. and its length ½ in.; then large radius fillets, and then came the effective testing length, which was 2 in., and its diameter 0.564 in. The overall length of the 1.2-in. bar would be about 7 in. Tests seemed to indicate that if one started with a 1.2-in. cast bar and reduced the test diameter down to about ½ in., one would quite possibly get a higher strength. Again, if one gripped the test-bar in the ordinary way—one could either screw it (as would probably be done in most cases) or could use split grip wedges—there might be a high skin stress due to slight distortion. The diameter of the bar should be reduced from 1.2 in. to 0.564 in. in two stages, so that, although the skin stress at the grip ends was higher than the stress at the centre, it did not reach breaking stress, because of the smaller diameter in the gauge length.

Mr. Faulkner asked what was meant by the statement that the elasticity ought to be more than ½ per cent.

Mr. Vivian said he believed that at failure the elastic stretch was roughly ½ per cent.

His feeling was that one could be a good deal more certain with tensile and transverse test results than with the results of tests on trepanned test-pieces. According to his information, a trepanned test-piece was very small; it was, so to speak, gouged out of a casting; it had a very rough surface and was not at all attractive to look at as a finished test-piece. Furthermore, he understood that it was tested in shear, and he did not see any reason why there should be an exact correlation between shear, and tensile and transverse tests. It seemed much simpler to test cast iron in tensile and transverse.

Finally, he agreed that cast iron was a very diverse material, and his Paper was based on observations confined chiefly to ordinary grades of grey cast iron. Because cast iron varied widely he had tried to produce a method of calculation which was capable of a good deal of flexibility. He believed that the elastic characteristic of a good number of grades of cast iron was constant, but at the same time the tensile strength might vary widely, but these things were capable of calculation if the correlation between tensile and transverse could be accepted.

A Vote of Thanks.

Mr. V. Delport, proposing a vote of thanks to Mr. Vivian for his Paper, commented on the lack of unanimity as to the merits of the various methods of testing cast iron. In certain Continental countries, he said, as Mr. Faulkner had mentioned, the tensile test was not liked very much, apparently, and shearing tests on small test specimens were preferred. In America, however, some good results had been obtained from tensile tests; the test-pieces used were machined and polished, and the ends were threaded. The cost of producing such test-pieces, however, would be rather high for the average foundry.

It was generally admitted, he believed, that there was yet no precise mathematical relation between the results of the various tests—tensile, transverse, etc.—and there was no precise mathematical relation between the results of one test on test-pieces of different sizes, at least, in so far as these tests apply to cast iron. These questions, however, were being studied by the International Committee on Cast Iron Testing Methods. It seemed that the angle from which Mr. Vivian had studied the question was quite original; a great deal of work was involved in obtaining the results, and it was to be hoped that in due course his Paper would be made available to the International Committee.

One had no difficulty in extending the thanks of practical foundrymen to Mr. Vivian for his Paper, because the concluding remark was most encouraging, since it expressed confidence in the material in which they were interested. Apart from that, however, the Paper was one of the most interesting that had ever been presented to the Branch.

Mr. Marshall, who seconded, assured Mr. Vivian that practical foundrymen would find very great interest in the Paper when they had the opportunity of studying it at leisure.

The vote of thanks was carried with acclamation.

Mr. Faulkner, who was then occupying the chair, expressed the hope that Mr. Vivian would visit the London Branch and other Branches of the Institute in the future, and that he would also attend the annual meetings of the Institute, for at those annual meetings he would have the opportunity of meeting experts on testing from all parts of Great Britain, who were members of the Institute's Test Bar Committee.

Mr. Vivian briefly returned thanks for the opportunity given him to read the Paper before the London Branch, and for the invitation extended to him to visit the Branches in the future.

Mr. Faulkner intimated that, in accordance with the suggestion made by Mr. Delport, he would send a copy of the Paper to the chairman of the International Committee on Cast Iron Testing Methods.

XUM

Foundry Problems.*

By C. A. Howe.

On reading foundry literature, one is impressed by the number of different views expounded, and on making a comparison of these views in relation to any one subject, one finds that very little uniformity exists. For instance, what one expert considers a poor analysis is being used by another authority for a similar class of work with satisfactory results. There is, besides, a large number of opinions as to what constitutes suitable mixtures for the various foundry raw materials, such as sand, etc.

Yet, again, when visiting different foundries, one cannot help noticing what different methods are being used for the production of a similar class of work; some being more elaborate and expensive than seems necessary. On inquiry, one is told that these methods are not always used as a matter of choice, but from necessity, it being found extremely difficult to obtain good castings by the cheaper method, in that particular foundry. It is fairly obvious that, when two experts disagree as to practice, or when two foundries are forced to use entirely different methods to obtain the same results, factors other than those apparent must have a controlling influence on the work. Besides considering one or two foundry jobs that gave a great deal of trouble before successful results were arrived at, the object of this Paper is to examine one or two of these apparent contradictions in foundry practice, and to endeavour to discover the reason for their existence.

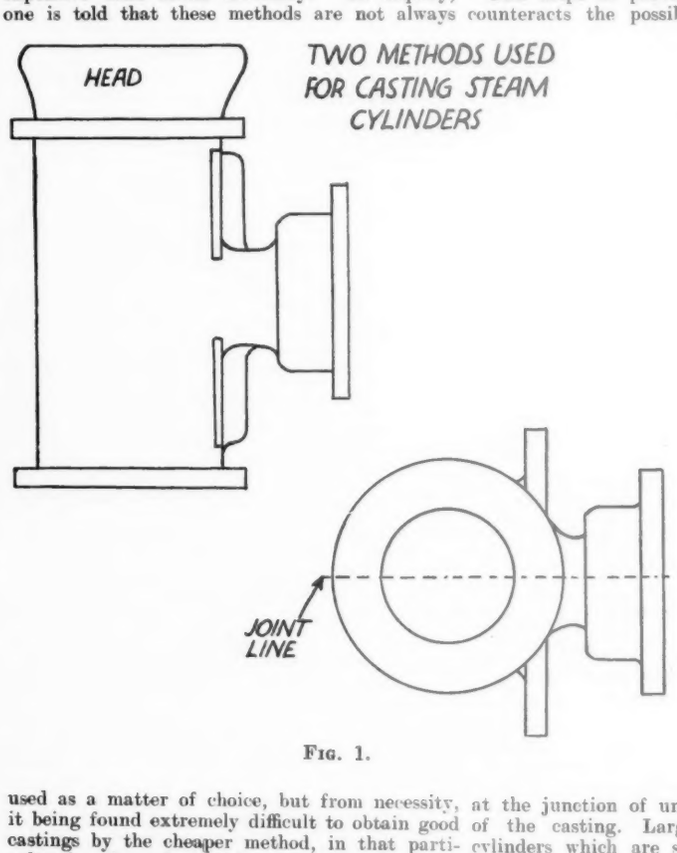

Fig. 1.

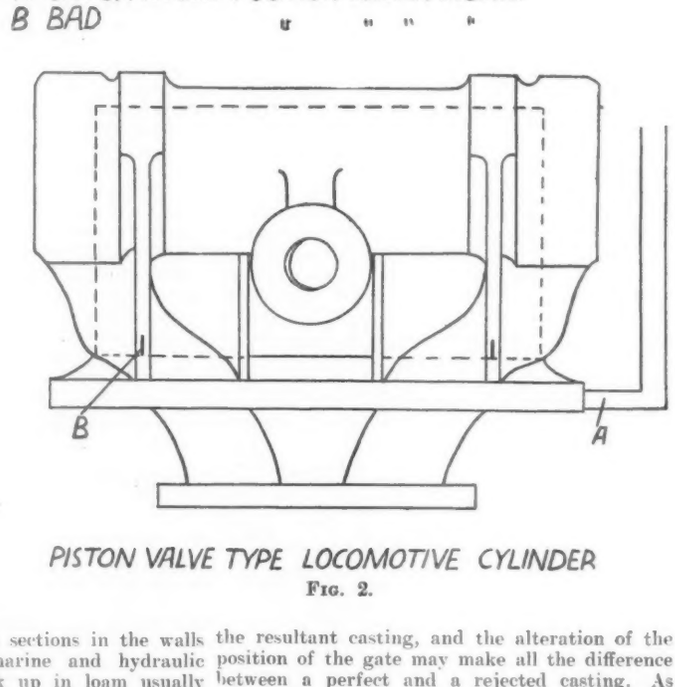

Fig. 2.

Moulding Practice.

The manufacture of steam and hydraulic cylinders is usually a source of trouble and anxiety. This is because they are invariably very complicated in design, and require a great deal of forethought before finally deciding upon the best lay-out for patternmaking, so as to ensure that the subsequent moulding and core-making operations be as easy and as straightforward as possible. Moreover, some foundries find it practically impossible to obtain a sound casting, clean in the bore, and not porous under test, when the barrel is cast in a horizontal position. Consequently they cast all their cylinders "on-end," with a heavy feeder head at the top. Of course, to most foundrymen, casting a cylinder "on-end" constitutes the better method of the two. This method greatly eliminates the possibility of dross accumulating in the bore, and the heavy feeder head, besides acting as a dirt trap and giving extra pressure, acts as a reservoir from which the molten iron can be drawn as the casting passes from the liquid to the solid stage.

This helps to prevent porosity, as it largely counteracts the possibility of cavities forming at the junction of uneven sections in the walls of the casting. Large marine and hydraulic cylinders which are struck up in loam usually lend themselves to casting "on-end," owing to the manner in which they are made, so they do not come within the scope of this Paper. However, in the case of smaller cylinders such as those for locomotives and steam engines, where patterns are used, it is often more difficult to allow for casting "on-end" owing to design. It is frequently far better for patternmaking and moulding to joint the pattern with the bore in a horizontal plane and to ram up the mould and assemble it in this position.

By far the cheaper method now is to cast the mould as assembled, but, as previously stated, some foundries find it extremely difficult to obtain a sound casting in this manner. Consequently they go the extra risk and expense of turning the box "on-end" and ramming it up in a pit before casting. To allow for this, chaplets and studs must be used more liberally than otherwise necessary to anchor the cores securely and prevent their moving as the moulding box is being up-ended. Now chaplets and studs are considered to be a source of trouble, porosity frequently being due to their use, especially when they are inserted in a casting subjected to high pressures, so naturally it is advisable to use as few chaplets as possible in such work. So, by up-ending the mould to cure one trouble another one is introduced, namely, the increased risk of porosity attendant upon the additional use of chaplets and studs.

Quite a number of foundrymen will commend the cautious worker and agree that the element of risk is greatly reduced by the time and trouble of casting a cylinder "on-end." But the point is that quite a number of foundries cast similar cylinders as assembled with the barrel in a horizontal position (Fig. 1), and get no higher percentage of rejects owing to dirty castings than those using the other method. So the question arises—"Why is it?"

Possible Causes.—The trouble may arise from a number of causes, and it is possible that the same troublesome factors are not only met with in the production of cylinder castings, but in the case of most castings that have to be machined.

In-gates.

Badly-designed or badly-placed gates are a frequent cause of dirty castings. Often, what at first sight appears to be the most convenient place for an in-gate, is not always the best for the resultant casting, and the alteration of the position of the gate may make all the difference between a perfect and a rejected casting. As dross collects in front of the flow of metal, the in-gate should be so placed that the metal may not flow directly under faces which will eventually be machined, such as the bore of a cylinder, but, if possible, the flow should be directed away from such faces, to pass under surfaces not requiring to be machined. In the latter case, should any dross enter the mould, there is less possibility of the machined surfaces being dirty, for the dross tends to remain under the faces where it collects, rather than to distribute itself all over the mould. This is shown in Figs. 2 and 3.

An in-gate which impinges directly against a core or any other obstruction is another source of trouble and may be the cause of subsequent porosity. The flow of metal against the core causes an accumulation of dross to gather in that spot. As the mould fills, the dross rises directly over the in-gates, and is trapped between the walls of the mould and the core. When the metal reaches a horizontal surface, it is apt to carry the lump of dross in its flow for a short distance, until it eventually lodges be-

* A Paper read before the Wales and Monmouth Branch of the Institute of British Foundrymen, Mr. Williams presiding.

tween the junction of two sections of the mould, and there remains. Later, when porosity shows up at that spot, it is quite possible that the uneven section of the metal will be blamed for the fault, or, in other words, the design of the casting, whereas it was actually the fault of bad gating, a fact overlooked, unless the casting is subsequently broken up for examination, and the real cause of the porosity ascertained, as is illustrated in Fig. 4.

Gating of Cylinders Cast "On-End."

Even cylinders cast "on-end" are not entirely free from the tendency to be dirty in the bore, for even these can be defective in that spot should the method of gating be bad, or the temperature of the molten iron lower than advisable. If one watches the casting of an open-sand-annular ring, poured from the bottom, a good idea can be formed as to what happens in the mould gated in a similar manner, when a cylinder is cast "on-end." It will be noticed that all the dross that collects on the surface of the metal does not eventually reach the top of the mould, but, as the rising metal cools off, is apt to cling to the wall of the mould (frequently the core); the metal then folds over it leaving the dross in that position. After the casting is machined, this dirt of course shows up.

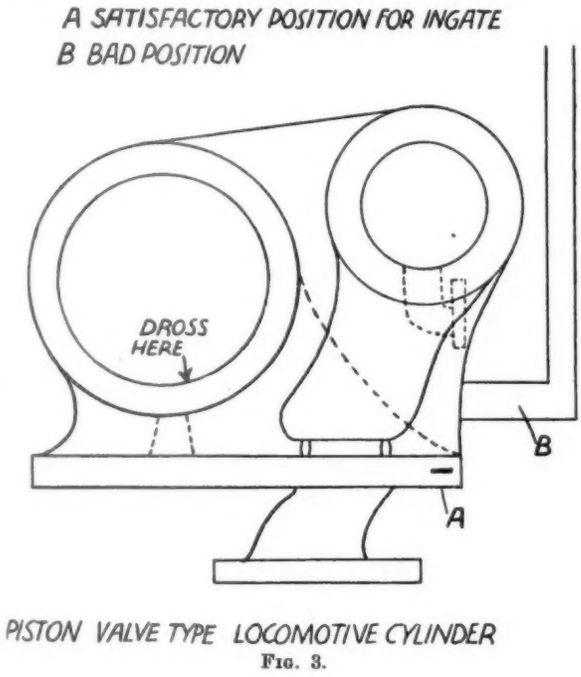

Fig. 3.

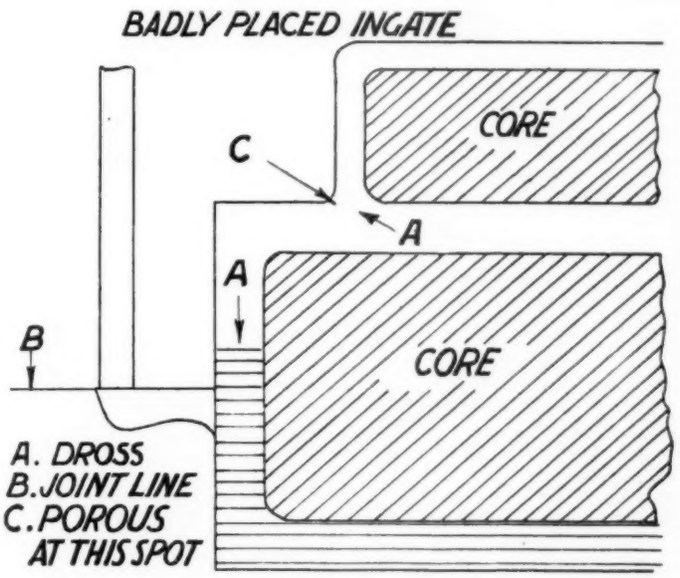

Fig. 4.

It has been found that by cutting the in-gate, so that it allows the iron to enter the mould at a tangent to the main barrel, helps to prevent the above trouble; the spinning action of the iron as it fills the mould preventing the dross from adhering to the sides. In spite of this, pouring direct from the top is more favoured. in this instance, the molten iron falling from a height, keeps the rising metal in a state of agitation, thus holding the dross in suspension, so that it rises to the top of the mould, without clinging to the side. But here, again, difficulties are apt to be experienced, for the metal dropping such a distance is liable to cut up the sand at the bottom. When such trouble is likely to arise, it is best to combine the two methods of gating—both bottom and top—allowing the mould to fill partially by the bottom gate before the metal is admitted by those at the top.

By this device the benefits of both methods are obtained, without the drawbacks of either, for the metal entering the bottom gate fills the lower part of the mould first and acts as a cushion upon which that entering from the top later may fall, and so prevent any cutting of the mould, whilst the hot metal admitted from the top prevents dross from clinging to the mould, thus giving a clean casting.

The Cupola.

Bad moulding and indifferent gating are not the only reasons of rejected castings; it is often possible to trace the trouble either to the metal itself or to the methods used in melting it. If the melting unit of a foundry is not working efficiently, and the iron not melted under the best conditions, no matter what care has been taken in the shop in the preparation of the mould, the chances of the resultant castings being sound are considerably lessened. In casting a cylinder or machined casting, it will be found from experience that the hotter the metal is teemed, the greater is the chance of the casting machining up clean and being sound under pressure. Now, it will be found that different foundrymen have different ideas as to what constitutes a really hot iron, and what is considered hot by one is just an ordinary heat to another.

As pyrometric control is not possible in all foundries, owing to economic conditions, etc., in such instances, visual judgment has to be relied upon. Even by this method it is not impossible to collect valuable data for future reference, for, although there is no calibrated table from which to take a reading of the degree of temperature, the colour of the metal is a good guide as to its heat, especially when constantly working with a similar grade of iron. To ensure obtaining a sound, clean casting by optical judgment, a cylinder iron should be dazzling white as it leaves the cupola, well above the orange and bright yellow shades, and cast as quickly as possible as soon as sufficient metal has collected in the ladle. The mould should be made to withstand the heat of the iron rather than the metal being cooled off to suit the mould, as is often the case.

If the results sought are not being obtained from the cupola and the metal is coming down dull—in the orange or dull yellow shades—there are quite a number of factors that may be held responsible.

Coke.—The grade of coke used may be of an inferior quality—with a high ash-content—and consequently not giving the desired thermal efficiency. If such be the case it would be advisable to try a fresh supply of coke, and if this be not possible, to increase the amount charged. Even when using a good grade of coke, the metal may not be brought to a sufficiently high temperature owing to the intervening charges of coke being too light. Although it gives great satisfaction to be able to state that one is melting at a very low coke-to-iron ratio, it is not good practice should it be at the expense of sound castings.

Blast.—Another vital factor in the efficient working of a cupola is the blast supply. It is just as essential that a known quantity of air be supplied to a cupola to melt a known quantity of iron, as it is to weigh the coke added. Both coke and air can be considered as fuels—for one supplies the carbon and the other the oxygen necessary for combustion, and these two elements when united in the proper proportion, produce the intense heat necessary to melt and superheat the iron. It will be realised from this that if the air supply is inadequate or in excess of requirements, it is bound to have some detrimental effect upon the working of the cupola, and, as a matter of fact, the iron itself. Care should be taken that the size of the blower or fan be adequate to supply the needs of the cupola to which it is connected; the blast pipes should be large enough in area to deliver the air supplied without undue losses owing to friction, and there should be no hindrances to the flow of the blast, such as projections, or sharp bends in the main. Lastly, the tuyere area also should be sufficient to supply the requisite amount of air.

In the matter of tuyere area, foundry authorities vary—some recommend a comparatively small tuyere-area and high-blast pressure, whilst others prefer large tuyeres and a low pressure. It is claimed by the latter, that air supplied at a high pressure has a detrimental effect upon the iron melted, as it sets up a forge action in the cupola, causing the oxygen in the blast in addition to entering into combustion with the coke, to react upon some of the elements contained in the iron—passing them off in the form of gas or in the slag. This would alter the chemical composition of the iron considerably, and give an entirely different analysis from that expected. It is not proposed to deal with occasional faults, such as bad lighting, scaffolding, etc.—which are liable to cause defective metal, but only to those which are likely to become a continual source of trouble.

Metal.

To obtain a satisfactory casting it is also necessary to select a grade of metal suitable for the job to hand. It will be found that one grade of iron is not suitable for every class of work, so by experience and comparison, one is able to determine upon suitable mixtures of pig-iron and scrap metal to obtain any specific results. It will be seen from the foregoing that there are a number of factors that govern the production of a good casting and many things that can go wrong. Some of the faults arise from very trivial causes which are apt to be overlooked by those in charge if they are not familiar with them, and, in consequence, the reason for castings being rejected is often attributed to everything but the actual cause.

Possibly this is why some foundries still adhere to antiquated and expensive methods, not having been successful when attempting new ones, though it must be added that some shops are still content to use the methods employed for the past 30 or 40 years in their foundries, and see no reason why they should go to the trouble and expense of altering existing tackle and patterns. But the foundry that experiences continual trouble would be wise to check over the items which have been dealt with as likely seats of trouble. Having rectified any errors they will be in a position to compete more successfully with the present keen competition.

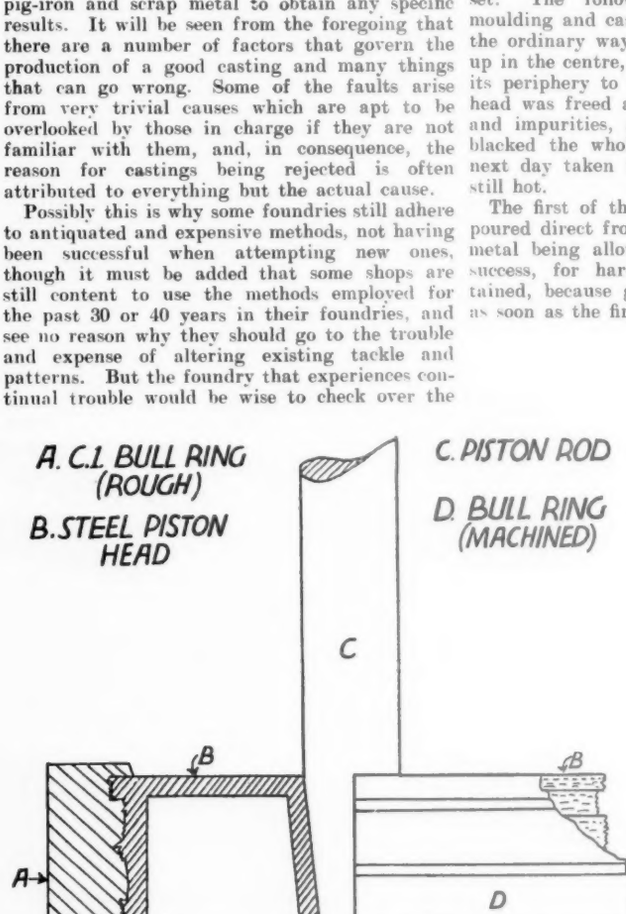

Fig. 5.

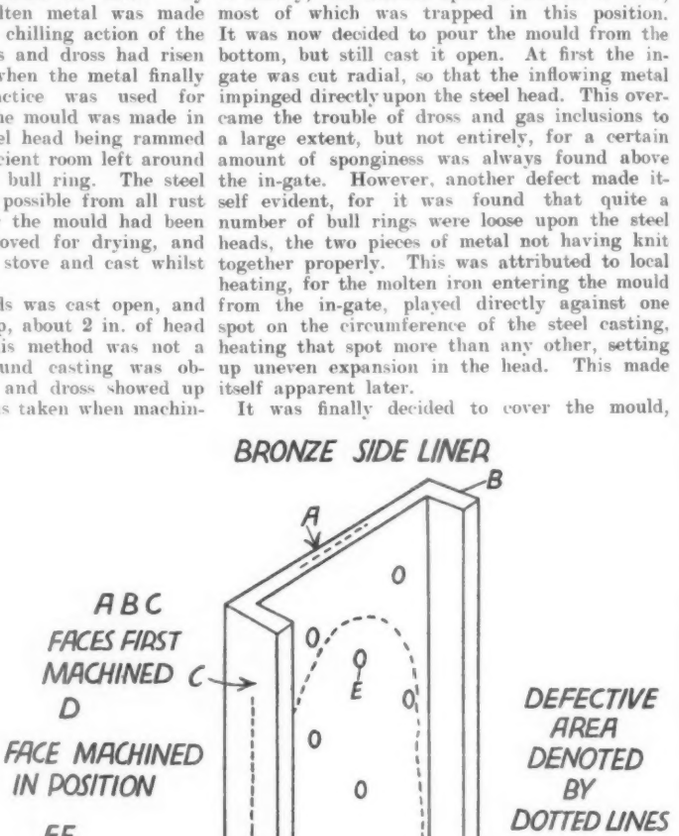

Fig. 6.

A Difficult Foundry Proportion.

Another job which the foundry is often called upon to perform, and one which frequently gives much trouble, is that of casting iron or brass around another metal object, and of obtaining a flawless casting after it is machined. The chief defects met with in this type of work are occluded gases and dross, and the cast-on metal is occasionally found to be loose, and not fitting tightly to the part on which it is cast. A number of methods are advocated, as preventing these faults, some with good results and others with very doubtful success. Let us consider casting a cast-iron bull ring around a steel piston head (Fig. 5) and discuss some of the methods used before success was eventually obtained.

It was found that to obtain anything like a sound casting it was useless to work to the ordinary machining allowances, for, by doing so, the wall of metal around the head was so thin that it had no chance to free itself from gases and dirt before it set. Consequently it was found necessary to increase the diameter by 2 in., the surplus metal being machined off later. By doing so the wall of molten metal was made thick enough to resist the chilling action of the steel head, until the gases and dross had risen to the top of the mould when the metal finally set. The following practice was used for moulding and casting. The mould was made in the ordinary way, the steel head being rammed up in the centre, and sufficient room left around its periphery to form the bull ring. The steel head was freed as far as possible from all rust and impurities, and after the mould had been blacked the whole was stoved for drying, and next day taken from the stove and cast whilst still hot.

The first of these moulds was cast open, and poured direct from the top, about 2 in. of head metal being allowed. This method was not a success, for hardly a sound casting was obtained, because gas holes and dross showed up as soon as the first cut was taken when machining commenced. At first it was thought that the steel piston head was the chief source of all the trouble, and that some rust or foreign matter must have been left upon its surface. This was thought to have been reacted upon by the heat of the molten iron, and the gases so liberated trapped in the metal before they had an opportunity of escaping. Great care was then taken to clean and polish the face of the piston, but this was extremely difficult, as the face to which the iron had to be cast had been roughly grooved in order to act as a grip to the bull ring. Still no better results were obtained, and upon careful examination of a whole batch of defective castings, it was found that in all instances the gas and dross inclusions were not evenly distributed around the head, but were far worse in one spot, and then gradually diminished in number and size, until at a spot exactly opposite on the diameter, the trouble had practically disappeared, and the metal was perfectly sound.

It was then concluded that the method of pouring was at fault, for it was proved that the excessively dirty spots appeared exactly where the metal was teemed into the mould. This was caused because the molten metal was poured direct from the ladle into the mould; the long distance the metal had to fall agitated it unduly, and formed upon its surface a scum, most of which was trapped in this position. It was now decided to pour the mould from the bottom, but still cast it open. At first the in-gate was cut radial, so that the inflowing metal impinged directly upon the steel head. This overcame the trouble of dross and gas inclusions to a large extent, but not entirely, for a certain amount of sponginess was always found above the in-gate. However, another defect made itself evident, for it was found that quite a number of bull rings were loose upon the steel heads, the two pieces of metal not having knit together properly. This was attributed to local heating, for the molten iron entering the mould from the in-gate, played directly against one spot on the circumference of the steel casting, heating that spot more than any other, setting up uneven expansion in the head. This made itself apparent later.

It was finally decided to cover the mould, placing two or three risers off the top, and to continue the gate the bull ring from the bottom, but to cut the in-gate at a tangent to the mould, in such a manner as to ensure that the inflowing metal would not play against the casting. Also, the head was well coated with a mixture of oil and blacking before it was stoved. This overcame all previous difficulties, for it was a rare thing for a head to be dirty or defective in any way, after these methods had been introduced.

The foregoing is an example of how one can be misguided by current opinion and led to look in the wrong directions for the cause of various defects. Most foundrymen will agree that to cast metal to metal is a difficult proposition, and more often than not the solid metal is blamed for all the defects found later in the casting. In this case the steel heads were thought to be giving the trouble, but later this was disproved, for good castings were obtained from the same heads, when suitable moulding practice was employed.

A Hidden Defect.

The following is an account of another type of casting where many failures were experienced before the cause was properly located. It also

shows how misleading a metallurgist's report may be, if not taken in conjunction with practical conditions; and also, how essential it is to take even the smallest items into consideration when seeking for the cause of defective castings. Phosphor-bronze side-liners for locomotive axle boxes (Fig. 6) were being cast in large numbers, and, after they were partially machined, were placed in stores and drawn on for use as the necessity arose. They were machined on three surfaces, and countersunk rivet holes drilled over the face, to enable them to be fixed to the axle boxes later. After the liners had been machined they were sent to the inspection department, and as no flaws could be detected they were passed into stores. However, it was not until the side liners had been finally fitted to the boxes and the machining on the other face completed, that the defect made itself apparent. Often, when the final cut was being taken, a rough surface was exposed extending over practically the whole area of the face. It appeared as if the castings had split down through the centre, dividing them into two plates, but the cracks did not extend to the outside edge of the liners, but stopped about half an inch in. Examination of other liners showed flaws right in the centre of the rivet holes.

As the cracks appeared extremely jagged and the surface highly coloured, samples of the metal were sent to the chemist to see if he could locate the trouble. Analysis showed the composition of the alloy to be correct, but it was suggested that the metal had been overheated during melting, the highly-coloured fracture pointing to this. Greater supervision over the melting was recommended. This put everyone on the alert in the foundry, but the increased supervision was probably the cause of the alloys not being properly melted, as the furnacemen erred on the side of caution, causing quite a lot of the general run of castings to be defective from that source.

A trial batch of liners was made and the melting of the metal carefully controlled, and it was agreed that no overheating had taken place. However, the defect still showed up in some of the castings, so it seemed to point to the fact that the melting had not been at fault. To minimise the risk, the foundry went to the inconvenience of casting these liners "on-end." Later, another order of liners was being made by the old method, that is, cast on their flat, and it was not until then that the real cause of the defect was found. These moulds were made on a moulding machine, and when 30 to 40 were assembled they were weighted and clamped and the molten metal brought up for casting. As is largely the practice, the men had only weighted sufficient moulds to take the metal contained in the ladle, and after the cast had been made and the ladle returned to the furnace to fetch more metal, the men began to move over the weights for the next cast, which took place straight away. Although the clamps were not removed from the boxes, the thought occurred that the early removal of the weights was causing the trouble, so the men were not allowed to remove the weights after the next cast, but were told to fetch other weights for the remaining moulds. Next morning a few of the castings were cut up, and it was found that those from which the weights had been removed were defective—split through the centre—whereas the others were perfectly sound. This proved conclusively that all along the defects had not been caused by overheated metal, but owing to an error in the shop.

These liners were cast in phosphor bronze, and were made in moulding boxes without any cross bars in them. Now, as most foundrymen know, phosphor bronze is an alloy that has a tendency to swell after it has set, but is still at a red heat. What had actually been happening was that the moulds had not been left weighted sufficiently long to allow the castings to become perfectly solid. Although the clamps had been left on the boxes the growth of the metal had been strong enough to push up the sand in the top box slightly. The defect did not make itself apparent on the outside of the casting because the cold walls of the mould solidified the outside surface of the casting at once, but the interior was defective, because the growth of the bronze had caused the casting to split right down through the centre, where it was still in the pasty form. This did not show up until after the casting was machined.

The Specification and Analysis of Cast Iron.

In the course of experience it is frequently found that definite analyses are laid down as being suitable for the different grades of grey-iron or semi-steel alloys. After a few years' practical experience one realises how difficult it is to work to strict analysis, owing to the inconsistency of the materials dealt with. The more practical way would be to allow certain margins of variation for each of the elements, as this would give the founder greater chance of producing the desired result.

Judging from analysis, cast iron is one of the most unstable metals with which a foundryman has to work. It is fairly safe to assert that if sample drillings were taken from the same pig, thoroughly mixed, divided into four equal parts and sent to different chemists for analysis, no two reports would give exactly the same result. True, these variations would not be great, but still sufficient to make a slight alteration in the character of the metal, for, with some of the elements—such as sulphur—an increase or decrease of even 0.01 per cent. is considered to have a marked effect on the properties of the metal. It is possible that these differences of analysis may be caused because the chemists do not employ similar methods in carrying out their experiments. The processes used are by no means standard, and slightly different results are reached from each of the methods of analysis. If this be so it would seem advisable that some method for the analysis of cast iron should be standardised. This would tend towards greater uniformity and help to prevent the occurrence of these variations.

Considering the very small quantities analysed, there is always the possibility that the smallest inaccuracy or loss during the analysis will be considerably enlarged when the final result is obtained. If, on the other hand, the metallurgists' analyses are to be taken as correct, it must be the composition of the iron that varies, and it will be realised how futile it is, to enunciate rigid specifications and expect them to be adhered to. It would be far better to state limits within which the various elements are to be kept. This would give the founder a greater opportunity of working to specification.

Another consideration is, that a truck of pig-iron does not appear to be homogeneous throughout. If separate analyses be taken from different pigs over the truck, varying compositions will be found. It is the practice to mix the drillings from the different pigs, and the analysis of the mixture is taken to be representative of the whole truck. So, when the pig-iron itself varies in composition it becomes increasingly evident that it is almost impossible to obtain consistent results after the metal has been re-melted.

Considering how difficult it is to work to strict specifications, it is strange to find different analysis laid down as being suitable for the same classes of work. Some of the analyses vary very slightly, whilst others show a wide divergence, as much variation as from 0.2 to 1.5 per cent. being noted in the same element. Now these analyses are made from irons that have been tested and found to give good service. The differences from 0.2 to 1.5 per cent. cannot be attributed to chemists' errors; it is too wide; it must be, therefore, that the composition of the metal varies to this extent. One wonders then whether a slight loss or increase over the specification to which one is working is as important as is generally supposed.

Take, for example, the analysis of irons recommended as suitable for Diesel-engine cylinder castings. Some authorities lay down the rule that the percentage of phosphorus should never exceed 0.5 per cent., whilst others claim that by using 1.0 to 1.5 per cent. of the same element they obtain an iron that gives satisfaction in every way. It is generally recognised in the trade that there should be no high phosphorus content in irons which are to withstand high temperatures, but 1.0 to 1.5 per cent. of phosphorus is an extremely high figure; yet the iron containing it is one that has been tried in service and approved. Now, what is the reason behind this contradiction between theory and practice? It would be interesting to know, since this is no isolated case; others of a similar nature will be found.

It is the practice to analyse iron for silicon, sulphur, phosphorus, manganese and sometimes carbon. Is it possible that the pig-iron contains traces of other elements than those usually analysed for, and that these have some unknown effect on the iron, or is it that the generally-accepted dictum of the trade is at fault and that a high phosphorus content in this particular iron is not as detrimental to efficiency as is usually supposed?

Each point raised in the Paper could be enlarged upon; for example, foundry practice differs in more than the two instances selected, and doubtless many here have met with other jobs than those described which have afforded them hours of weary work and cogitation before the problem was resolved. The lack of standardisation in foundry practice, and the unforeseen difficulties to be met with in tackling various classes of work have been made abundantly clear.

Works Management.

Mr. Harry F. Coggon, of August's, Limited, and chairman of the Yorkshire Branch of the British Works Management Association, speaking at the first meeting of the Branch in Bradford, took for his subject, "Works Management: its relation to Modern Industry." He said the enlightened works management of to-day tended its labour with considerable care. It appreciated both the economic and the human value of welfare work and the value of improving the standard of life. It could not be doubted, continued Mr. Coggon, that the relationship of works management to modern industry became clearer and more important every day. Works management fulfilled a position—the pivotal position—at the very foundation of modern industry. The effects of modern industrial conditions upon production were vital, and industrial progress and industrial supremacy could only be obtained by works management taking the fullest possible advantage of the benefits which the application of modern developments would give. It was therefore incumbent upon the works manager to study the relationship of his position to modern industrial conditions and to keep himself fully in touch with them.

Chromium in Cast Iron.—According to Mr. Charles O. Burgess, the addition of small amounts of chromium (0.25 to 0.50 per cent.) produced a definite improvement in the strength, deflection and density of the cast irons investigated. On the addition of chromium, there was marked improvement in uniformity of hardness in varying sections, particularly with respect to the retention of hardness in heavy sections. A distinct improvement in the heat-resisting properties of cast iron was effected by the addition of a small amount of chromium. This improvement was related to a stabilisation of the pearlitic structure of the irons and an increased resistance to growth at high temperatures. The machinability of cast irons containing small amounts of chromium is not adversely affected even though the hardness is moderately increased.—Technical Publication No. 492 of the American Institute of Mining and Metallurgical Engineers.

This Week's News in Brief.

Trade Talk.

A further 150 men resumed work at the Mond Nickel Works, Clydach, last week.

Messrs. Stewarts & Lloyds' Clydesdale steelworks, Mossend, started work last Monday.

The International Zinc Cartel has been renewed for another year from January next.

The Shotts Iron Company, Limited, have reopened their Southfield Pit, Shotts, which had been closed since last May.

The Admiralty is being urged to enlarge its list of firms which are permitted to tender for naval shipbuilding contracts.

The Russian Government has placed in this country an order for 25,000 tons of steel plates, which has been allocated among the principal British firms.

Working tests were made at Chesterfield last week on the driving of an omnibus on coke-oven gas from high-pressure cylinders instead of petrol.

The employees of Messrs. William Simons & Company, Limited, engineers and shipbuilders, Renfrew, have contributed the sum of £53 10s. to infirmaries and charitable institutions in the West of Scotland

Regarding the erection of the Showa Steelworks in Manchuria, it is understood that the South Manchurian Railway Company, on negotiation with the Yawata Imperial Steelworks, has decided to start the work of construction in the next business year.

It is understood that the Egyptian Government will shortly invite tenders for the construction of the hydro-electric plant to make use of the head of water which will be available when the work of heightening the Aswan Dam, which is now in progress, is completed.

The Normanby Ironworks of Messrs. Pease & Partners, Limited, at Middlesbrough, which have been closed down since July last, are to be restarted within the next week. There are three blast furnaces at the works and two of them will be put into operation on the production of hematite.

Messrs. Kitson & Company, Limited, have commenced manufacturing at their Airedale Foundry, Leeds, a new product, "Bricanion," which is a form of metallic lathing, consisting of a woven steel wire netting covered with brick-clay crosses, which are applied under high pressure before baking.

There are at present four furnaces in blast at the Skinningrove Iron & Steel Works. Owing to the scheme of development to be undertaken by the owners of the works, one blast furnace will be blown out, and the other three damped down. During the time the works are closed customers for pig-iron will be supplied from stock.

Steelworks in the West of Scotland are to secure a share of a Russian contract for 25,000 tons of steel plates. It is understood that the works which will benefit in the Scottish area will be Blochairn Steelworks, Glasgow; Clydebridge Steelworks; Clydesdale Steelworks; and the Lanarkshire Steel Company, Limited, Motherwell.

Messrs. Kayser, Ellison & Company, Limited, state that on October 1, £36,610 of the outstanding 6 per cent. debenture stock was paid off, leaving £38,810 extended for a further period of seven years to October 1, 1939. The interest has been reduced to 5½ per cent. per annum, in accordance with the terms of the offer made last April.

President Hoover has formally instructed the United States Tariff Commission to investigate 18 of the major industries to determine whether they are sufficiently protected. In doing so, Mr. Hoover remarked on the depreciation of the currencies of certain countries which has taken place. The list of industries includes cutlery, iron and steel products, and metal goods.

The members of the staff of Messrs. J. M. Henderson & Company, Limited, engineers and founders, Aberdeen, and their friends, held their annual social and halloween party in the St. Nicholas Hall on October 22. Mr. E. F. Watson, the organiser, presided at the supper. The evening was greatly enjoyed by all present, who entered enthusiastically into cards, songs and music.

The United States Steel Corporation has declared the regular quarterly dividend of $1.75 on the preferred stock. The Corporation reports a net loss in the third quarter of $20,871,709, compared with a loss of $20,452,173 in the second quarter, and a loss of $13,218,549 in the first quarter of the year. In the third quarter of 1931 there was a net loss, excluding non-recurring income, of $3,973,835.

There were no launches from Clyde shipbuilding yards during October. This is the second month this year in which no vessels left the stocks, thus creating a precedent in the history of the industry. The total tonnage launched during the ten months of 1932 is 43,645 tons, representing 20 vessels, while for the same period last year the figure was 140,881 tons, representing 48 vessels.

Messrs. Dorman, Long & Company, Limited, of Middlesbrough, are members of a new syndicate composed of British, French and German firms, which has been formed for the purpose of carrying out public works contracts abroad. The firms concerned are Messrs. Dorman, Long & Company, Holland & Hannen & Cubitts, and the Limmer & Trinidad Lake Asphalt Company, two French firms of contractors, and two German firms of contractors.

The works of Messrs. James & Frederick Howard, Limited, a branch of Agricultural & General Engineers, Limited, which closed down last February, is stated to have been bought by Mr. Le Bas on behalf of foreign interests for putting into commission as an iron and steel foundry. The London firm of that name is the agent for the famous Gebruder Fischer of Schaffhausen.

We learn that in addition to the three "Wellman" patent single-sheet normalising furnaces recently installed in South Wales, the Wellman Smith Owen Engineering Corporation, Limited, has just put down a further normalising furnace in Scotland. During the past few months the Corporation has received orders from the Continent for its new single-sheet normalising furnace. The "Wellman-Chantraine" patent system of firing is a feature of all these furnaces.

John A. Smeeton, Limited, steelworks and foundry engineers, 15, Victoria Street, London, S.W.1, have just appointed as their district agents the following:—Messrs. Wm. H. Flood & Company, Limited, Prudential Buildings, Pinstone Street, Sheffield, 1, for Derbyshire, South Yorkshire and Staffordshire; Mr. C. H. Faris, 2, Marland Avenue, Cheadle Hulme, for Lancashire and Cheshire; and J. Glanville Davies, Llwyncelyn, Hafod, Llanelly, for South Wales.

Messrs. William Denny & Bros., Limited, Dumbarton, have received an order to build a passenger vessel for service on the Jersey-France route of the Southern Railway Company. The new vessel will replace the "Vera," which was built at Clydebank in 1898, and a condition of the contract is that she shall be ready by June of next year for the summer holiday traffic. She will have accommodation for 900 passengers. The firm have another Southern Railway boat in hand, which will be launched during November.

Wild-Barfield Electric Furnaces, Limited, Elecfurn Works, North Road, Holloway, London, N.7, in co-operation with the City of Sheffield, are arranging a demonstration of modern types of electric heat-treatment furnaces at the Electric Supply Department's Sheaf Street Works (corner of Shude Hill and Sheaf Street), Sheffield, from Monday, November 7, to Saturday, November 12, inclusive. The various furnaces will be in daily operation from 10 a.m. to 6 p.m. (Saturday from 10 a.m. to 12.30 p.m.), the work and hardeners being kindly supplied by prominent Sheffield manufacturers.

An interesting ceremony took place at the East Kilbride works of Messrs. Mavor & Coulson, Limited, during the luncheon interval on October 28, when Miss J. B. Mavor planted a birch tree and Mr. Sam Mavor, the managing director, planted a horse-chestnut tree. These are the last two of 2,127 trees which have been planted all around the estate upon which the firm's new works are erected. Mr. Sam Mavor reminded the employees that ever since it started to leave the crowded conditions and impure air of the East End of Glasgow the firm had been determined to preserve the natural beauties it found in that lovely countryside. They wanted to give their employees as pleasant and enjoyable conditions as possible in which to work. The prizes for the men's flower and vegetable gardens were then presented by Miss J. B. Mavor.

Personal.

Mr. Robert Killin, general superintendent of the London Midland & Scottish Railway in Scotland, relinquished his office last week.

Mr. James Whitby has been appointed London manager of the Oriental Steel Company, Limited, which company now handles all the sales of galvanised sheets for the Indian market on behalf of the makers in the United Kingdom.

Mr. G. N. Guest, late managing director of Messrs. Hollings & Guest, Limited, hydraulic engineers, and also of Messrs. Hands & Sons, Limited, power-press makers, has recently joined Messrs. Tangyes, Limited, Cornwall Works, Birmingham, in connection with the hydraulic machinery side of their business.

Wills.

Wilson, Joseph D., Paisley, steelfounder	£16,387
Martin, Hugh, J.P., Hughenden, Coatbridge, late of Dundyvan Iron & Steel Company, Limited	£23,631
Kuehnrich, P. R., of Sheffield, steel and razor-blade manufacturer, formerly managing director of Messrs. Darwins, Limited	£57

Obituary.

Mr. John Spencer, a prominent member of the Sheffield tool trade, died on Sunday, October 16.

Mr. John Gifford, managing director of Messrs. W. G. Bagnall, Limited, Castle Engine Works, Stafford, died recently. Mr. Gifford, who was 74 years of age, had been connected with the firm for 46 years.

Lieut.-Colonel Claude G. Bryan, a director of Palmers Shipbuilding & Iron Company, Limited, the South Pelaw Colliery, Limited, and the Amble Shipbuilding Company, Limited, died in London on Sunday, October 23.

Senator Giovanni Pirelli, the founder of the rubber-manufacturing firm which bears his name, and of the Pirelli-General Cable Works, Limited, Southampton, died recently at Milan, at the age of 84. He had many years ago retired from active business.

Mr. Frank Graham Fairbank has died at his home at Strensall, York, at the age of 75. Mr. Fairbank was a descendant of a well-known family of surveyors, who practised in Sheffield from about 1700 to 1850. He had been in practice for more than 50 years, and was senior partner in the firm of Fairbank & Son, chartered civil engineers, of York. He was responsible for the design of a large number of engineering works in Yorkshire and in other parts of England.

Contracts Open.

Aden.—Galvanised wrought-iron tubes and steel tank, capacity 100,000 galls., etc., for the Executive Committee of Aden Settlement. The Chairman, Aden Settlement, Aden.

Cairo, December 10.—Two Diesel engines, switchgear, a travelling crane and other workshop plant for the Local Commissions Section, Ministry of the Interior. The Department of Overseas Trade. (Reference A. 11,530.)

Dublin, November 7.—Iron and steel stores, for the Dublin United Tramways Company, 59, Upper O'Connell Street, Dublin.

New Delhi, November 10.—100 platform wagons, 2 ft. 6 in. gauge; 100 crane skips, and two 2-ft. 6-in. gauge steam locomotives, for the Indian Stores Department. The Department of Overseas Trade. (Reference G. 11,926.)

Singapore, November 7.—Galvanised iron tubes and fittings, for the Singapore Municipality. The Department of Overseas Trade. (Reference G.X. 11,917.)

Edgar Allen & Company, Limited, have put on the market a new alloy steel for blacksmiths' tools, *e.g.*, chisels, sets, etc. This steel is known as "Maxmith."

Important Announcement to the FOUNDRY TRADE!

Established 1805.
Over 100 years of Service.

PARISH'S are the Original Moulding Sand Quarries of **Erith . .** Erith Loam - The Hall Mark of Time.

PORTION OF PARISH'S WORKING FACE ¼ MILE IN WIDTH.

Supplied in

Six Grades—MILD, MEDIUM, YELLOW, STRONG, EXTRA STRONG & OIL CORE.

QUALITY——Always the same. A face of 65 feet in depth assures deliveries true to type.

QUANTITY——A recent survey shows millions of tons in sight.

DELIVERY——The only Erith Quarry with facilities for water borne traffic. Your ships can call at our Wharf. From our Rail Siding to yours. Large fleet of Steam and Petrol Vehicles.

REPUTATION—The Text Books describe it. The World knows it and the Foundries appreciate it. PARISH'S have had the confidence of the Trade for over 100 years. Still the cheapest because it's the best.

Genuine PARISH'S Erith Loam obtainable only from

JOHN PARISH & CO.,

ERITH,——————————KENT.

or the following accredited Agents

BIRMINGHAM DISTRICT, POTTERIES & MIDLANDS—
William James, Mineral Merchant, Derby.
DUNDEE—
Brown & Tawse, Kandahar House, 71, Meadowside.
GRIMSBY & LINCOLNSHIRE—
S. L. Goldthorpe, 405, Victoria Street, Grimsby.
PENRYN & FALMOUTH (for Cornwall)—
Norman S. Furneaux, Penryn.
HULL & SOUTH YORKSHIRE—
E. E. Tottle & Son, 31, High Street, Hull.
LONDON (North of River Thames)—
Erith & Co., Ltd., Midland Wharf, Bow, E.3.
SCOTTISH MIDLANDS—
Robert Crawford & Co., Grangemouth.
TYNE & TEES DISTRICT—
Durham & Cleveland Trading Co., Ltd., Erimus Chambers, Middlesbrough.

Competitive Prices. Efficient Service. Better Castings.

Samples, post or rail, free on application.

Raw Material Markets.

It is generally considered that conditions in the iron and steel markets are now more favourable. A quiet, but steady, business has been done in pig-iron, although there are still considerable stocks at the furnaces. Continental competition has practically ceased for the time being in the semis market. The home works have received more orders, but, as most consumers have good stocks in hand, business has mainly been from hand to mouth. Owing to the depression in the heavy industries, the home consumption of finished steel is restricted, and hopes are centred on an improved market overseas.

Pig-Iron.

MIDDLESBROUGH.—Owing to the stoppage of four blast furnaces in this area, three of which have been producing Cleveland iron, the district will be left with only three blast furnaces producing Cleveland iron, and the output of one of these is entirely absorbed in the makers' own works. When stocks have been reduced, it may be expected that the output will be increased. At the moment, however, the demand for Cleveland iron is still limited, as most of the foundries in Scotland and the North of England are very slack. Quotations are:—No. 1 Cleveland foundry iron, 61s.; No. 3 Cleveland G.M.B., 58s. 6d.; No. 4 foundry, 57s. 6d.; No. 4 forge, 57s. per ton.

The outlook is brighter in the hematite market. The number of blast furnaces producing East Coast hematite has been increased to seven, but will be reduced at the end of this week. Competition in this branch of the trade is keen, rendering more remote the advance in prices for which some of the producers have been hoping. However, low prices have attracted foreign buyers in this district, and a few small sales to Italy and Denmark have been negotiated.

LANCASHIRE.—The aggregate requirements of pig-iron are barely maintained on the very moderate scale of the past few months. Order books of most foundries, especially the general foundries and those concerned with the manufacture of textile machinery, are not such as to justify large-scale buying operations. Derbyshire, Staffordshire and North-East Coast brands are on the basis of 67s. per ton, including delivery in the Manchester zone, Northamptonshire is at 65s. 6d., Derbyshire forge at 62s., Scottish foundry at from 83s. to 84s. and West Coast hematite at around 81s.

MIDLANDS.—This area remains in a depressed state, and business is quiet. Little inroad is being made into the extensive stocks which exist. It is hoped that, now that the position with regard to imported material is precisely known, conditions may shortly improve. Prices are unchanged at 62s. 6d. for No. 3 Northants and 66s. for North Staffordshire, Derbyshire and Lincolnshire No. 3, including delivery to Birmingham and Black Country stations. Medium and low-phosphorus qualities are coming through from Scotland and other sources at prices ranging from 70s. to 86s. 6d., the Scottish rates being upwards of 83s. 6d. Small quantities of Cleveland No. 3 are coming through into this area at 66s., delivered Midland stations.

SCOTLAND.—The market lacks interest, and there is much idle time and plant. The official minimum price of 67s. 6d. f.o.t. furnaces for No. 3 foundry iron is unchanged, with an extra of not less than 2s. 6d. per ton for No. 1. No. 3 Middlesbrough is at 55s. 6d. at Falkirk and other English irons at about 54s., but the demand is very limited.

Coke.

Although other sections of the coke trade are active, the demand for blast-furnace coke is extremely dull. Consumption seems likely to decline still further, owing to the stoppage of more blast furnaces. There have been no alterations in prices of foundry coke. Consumers are reluctant to cover forward, although there is usually a disposition on their part to do so for the winter months. Delivered Birmingham district, 36s. 9d. to 38s. is quoted for best Durham fuel and from 30s. to 45s., according to analysis, for Welsh supplies.

Steel.

The weekly report of the London Iron and Steel Exchange comments on the absence of Continental competition in this country, the low exchange value of sterling plus the import duties having made Continental steel more expensive than the British product in the home market. These conditions have, of course, benefited the British manufacturers, but the volume of business transacted has not been so large as might have been expected, owing probably to the large stocks which are held in the country and the number of old contracts in existence against which delivery has not yet been made. The demand for semi-finished steel has not been active. Business in finished materials has been quiet, and, in spite of the depreciation of sterling, British makers are finding Continental material keenly competitive in the export markets. Rather more business has been done with the Far East of late, and inquiry from other overseas markets has increased.

Scrap.

In the Cleveland market there has been a slight upward movement, and at the weekly market this week there were buyers who were prepared to pay 35s. per ton as a delivered price for heavy-steel scrap. Ordinary cast-iron scrap is at 35s., and machinery quality 36s. The Scottish market remains depressed, although there have been one or two more openings for heavy-steel and heavy-basic scrap, on account of a few more melting furnaces restarting. Ordinary cast material suitable for foundries and in pieces not exceeding 1 cwt. is at 39s. In South Wales heavy cast-iron in large pieces and furnace sizes is weak at 37s. to 39s., while supplies of good cast-iron machinery scrap for foundry purposes are offered at 45s.

Metals.

Copper.—The market has been somewhat unsatisfactory during the past week, as buyers were unwilling to commit themselves before the conference of producers was held. Perhaps the most interesting clause in the text of the agreement reached between the producers and consumers on the subject of Empire copper concerns the definition of "world price." The clause reads: "With regard to world price, the producers and the consumers agree to adopt as world price the London Metal Exchange quotations for copper, exclusive of duty, it being understood (*a*) that if separate quotations should in future be made for Empire copper and for non-Empire copper, the latter quotations shall be adopted for the purpose of this Agreement, and (*b*) that neither the producers nor the consumers nor the Government are bound to adhere to this method of determining world price if in future it is found that it does not provide the safeguards contemplated by the Ottawa Agreements. As regards the question of differentials in the case of fire-refined and Bessemer copper, it is agreed to accept the principle that the United Kingdom consumers shall not be at a disadvantage as compared with foreign consumers."

Closing quotations :—

Cash.—Thursday, £30 11s. 3d. to £30 13s. 9d.; Friday, £30 10s. to £30 12s. 6d.; Monday, £30 5s. to £30 6s. 3d.; Tuesday, £30 5s. to £30 6s. 3d.; Wednesday, £29 18s. 9d. to £30.

Three Months. — Thursday, £30 15s. to £30 16s. 3d.; Friday, £30 13s. 9d. to £30 16s. 3d.; Monday, £30 8s. 9d to £30 10s.; Tuesday, £30 8s. 9d. to £30 10s.; Wednesday, £30 2s. 6d. to £30 5s.

Tin.—There has again been great irregularity of prices this week, although values have had a tendency to harden. There has been a slight improvement in the Continental demand, and a moderate amount of business has been done with America. Russia has again been in the market. Business has been hindered by the wide fluctuations in sterling. Consumptive demand on both sides of the Atlantic is spasmodic.

Official closing prices :—

Cash.—Thursday, £152 17s. 6d. to £153 2s. 6d.; Friday, £152 17s. 6d. to £153 2s. 6d.; Monday, £152 10s. to £152 15s.; Tuesday, £152 5s. to £152 10s.; Wednesday, £152 2s. 6d. to £152 5s.

Three Months.—Thursday, £153 10s. to £153 15s.; Friday, £153 12s. 6d. to £153 15s.; Monday, £153 7s. 6d. to £153 10s.; Tuesday, £152 17s. 6d. to £153 2s. 6d.; Wednesday, £152 17s. 6d. to £153 2s. 6d.

Spelter.—Consumers' demand in this market has been meagre. At no time has there been any selling pressure, prices simply easing from general lack of interest. Galvanisers report that they find business very dull indeed. The fact that the Zinc Cartel is to be continued and that stocks are still to be reduced indicates the apparent soundness of zinc.

Daily fluctuations :—

Ordinary.—Thursday, £15 1s. 3d.; Friday, £15 2s. 6d.; Monday, £15 2s. 6d.; Tuesday, £15 1s. 3d.; Wednesday, £15 2s. 6d.

Lead.—The lead market remains dull and uninteresting. Very little interest is being taken either by consumers or dealers. Perhaps the outstanding event recently has been the protest issued on behalf of the British Accumulator Makers' Association against the working of the tariff on lead. The accumulator makers claim to use about 30,000 tons of lead a year (about one-eighth of the total British consumption), and allege that they are severely handicapped in their endeavours to secure export business in competition with manufacturers who can buy at the Metal Exchange price without any premium.

The week's prices have been :—

Soft Foreign (Prompt).—Thursday, £11 12s. 6d.; Friday, £11 15s.; Monday, £11 16s. 3d.; Tuesday, £11 17s. 6d.; Wednesday, £11 13s. 9d.

British Foundry Units, Limited.

FOUNDRY SUPPLY COMPANIES AMALGAMATED.

Our readers will be interested to learn that an amalgamation of certain interests has been effected between Messrs. Beecroft & Partners, Limited, Retort Works, Mappin Street, Sheffield, and Messrs. J. & J. Dyson, of Chesterfield.

Messrs. Beecroft & Partners, Limited, have progressed steadily for a number of years, the company being formed in 1920 at Chesterfield. In 1923 they moved to St. Peter's Close, Sheffield. In 1928 the products department was moved to Retort Works, Mappin Street, Sheffield, and the business of analysts and testers carried on at St. Peter's Close, Sheffield, the laboratories being extended for this purpose.

Messrs. J. & J. Dyson, Limited, are an old-established concern, having been connected with the production of refractory materials for foundry and steelworks use for many years. The Chesterfield works were opened in 1910 for the production of gas-fire radiants and fuel, and later, in 1924, for the production of foundry blackings.

Both concerns are well known throughout the foundry trade in the British Isles, and, indeed, in other parts of the world, an appreciable export business having been carried on for some years. The union is thus a particularly happy one, and it is anticipated that the result will be increased production and turnover. Messrs. Beecroft & Partners, Limited, are closing down their present works at Mappin Street, Sheffield, and removing to Chesterfield to the freehold works and land (now occupied by Messrs. J. & J. Dyson, Limited), which have been bought over by the new company.

There are three acres of freehold land with large shops and office accommodation to which will be added a large new building to house the gas-fire radiant and fuel department. The present shop in which these are produced will be converted in such a manner as to be suitable for the manufacture of Beecroft's core oils, compounds and fluxes, etc. There is ample yard room and the factory adjoins the main L.N.E. Railway line from Sheffield to Chesterfield.

New general and private offices on a modern plan are being erected at the entrance to the works; their private road and the general lay-out of the offices and factory is being carried out on most generous lines. The ultimate outcome of the amalgamation will be an up-to-date foundry supply company producing everything required in an iron, steel or brass foundry from a chaplet to a cupola.

Messrs. Beecroft & Partners (Metallurgists), Limited, will still carry on their activities at St Peter's Close, Sheffield, under the above title, solely on analytical, testing and general foundry consultation work, and will constitute one of the most up-to-date research and commercial laboratories in Great Britain, the control being under experienced metallurgists and engineers of many years' experience and standing.

XUM

universally recognised as the leading brand of Cylinder Pig Iron

WARNER

CBR

The way to BETTER castings

WARNER & CO. LTD. CARGO FLEET MIDDLESBROUGH

CAST IRON FLANGED PIPES

2 in.—12 in. & CONNECTIONS. to 24 in. dia.

WE HAVE FIFTY-TWO YEARS OF ACCUMULATED EXPERIENCE AND METAL PATTERNS.

JAMES & RONALD RITCHIE, LTD.,

Telephone: 3852 (2 Lines). MIDDLESBROUGH. Telegrams: "Ritchie, Middlesbrough."

WEEKLY PRICE CURRENT.

COPPER.

	£ s. d.
Standard cash	29 18 9
Three months	30 2 6
Electrolytic	34 15 0
Tough	32 5 0
Best selected	32 15 0
Sheets	65 0 0
India	44 5 0
Wire bars	35 15 0
Do., Dec.	35 15 0
Do., Jan.	36 5 0
Ingot bars	36 15 0
H.C. wire rods	37 15 0
Off. av. cash, October	31 18 7 13/14
Do., 3 mths., October	32 1 8 5/7
Do., Sttlmnt., October	31 18 8 2/7
Do., Electro, October	36 10 11 3/7
Do., B.S., October	34 15 0
Do., wire bars, October	36 18 1½
Solid drawn tubes	10d.
Brazed tubes	10½d.
Wire	7d.

BRASS.

Solid drawn tubes	9d.
Brazed tubes	11d.
Rods, drawn	8½d.
Rods, extd. or rlld.	5d.
Sheets to 10 w.g.	7½d.
Wire	7⅝d.
Rolled metal	7¼d.
Yellow metal rods	4½d.
Do. 4 × 4 Squares	5¼d.
Do. 4 × 3 Sheets	5½d.

TIN.

	£ s. d.
Standard cash	152 2 6
Three months	152 17 6
English	152 15 0
Bars	156 0 0
Straits	158 0 0
Australian	156 5 0
Eastern	157 15 0
Banca	158 5 0
Off. av. cash, October	151 7 6
Do., 3 mths., October	152 4 10 4/7
Do., Sttlmt., October	151 7 7 3/7

SPELTER.

	£ s. d.
Ordinary	15 2 6
Remelted	15 0 0
Hard	12 15 0
Electro 99.9	17 7 6
English	16 0 0
India	14 0 0
Zinc dust	22 0 0
Zinc ashes	2 5 0
Off. aver., October	15 0 1 1/16
Aver. spot, October	14 17 4 3/7

LEAD.

	£ s. d.
Soft foreign ppt.	11 13 9
Empire	12 7 6
English	13 10 0
Off. average, October	12 1 3 5/16
Average spot, October	11 19 2

ZINC SHEETS, &c.

	£ s. d.
Zinc sheets, English	24 10 0
Do., V.M. ex-whse.	23 0 0
Rods	27 0 0
Boiler plates	23 0 0
Battery plates	—

ANTIMONY.

	£ s. d.
English	35 0 0 to 42 10 0
Chinese	26 10 0
Crude	18 10 0

QUICKSILVER.

	£ s. d.
Quicksilver	10 0 0

FERRO-ALLOYS AND STEEL-MAKING METALS.

Ferro-silicon—	
25%	8 0 0
45/50%	13 15 0
75%	19 10 0
Ferro-vanadium—	
35/50%	12/8 lb. Va.
Ferro-molybdenum— 70/75% c. free of Mo.	6/3 per lb.
Ferro-titanium— 23/25% carbon-free	10d. lb.
Ferro-phosphorus, 20/25%	£20 0 0
Ferro-tungsten— 80/85%	1/7½ lb.
Tungsten metal powder— 98/99%	1/10½ lb.
Ferro-chrome— 2/4% car.	£34 5 0
4/6% car.	£25 15 0
6/8% car.	£24 10 0
8/10% car.	£22 5 0
Ferro-chrome— Max. 2% car.	£36 10 0
Max. 1% car.	£42 12 6
Max. 0·70% car.	£43 17 6
70% carbon-free	1/- lb.
Nickel—80/99.5%	£250 to £255
"F" nickel shot	£225 0 0
Ferro-cobalt	7/9 lb.
Aluminium 98/99%	£100 0 0
Metallic chromium— 96/98%	2/9 lb.
Ferro-manganese (net)— 76/80% loose	£10 15 0 to £11 5. 0
76/80% packed	£11 15 0 to £12 5 0
76/80% export (nom.)	£9 15 0
Metallic manganese— 94/96% carbon-free	1/4 lb.

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

Finished bars, 14% tungsten	2s. 0d.
Finished bars, 18% tungsten	2s. 9d.

Per lb. net, d/d buyers' works.

Extras—

Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to 3/16 in.	1/- lb.
Flats, ½ in. × ¼ in. to under 1 in. × ⅛ in.	3d. lb.
Do., under ½ in. × ¼ in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

SCRAP.

	£ s. d.	£ s. d.
South Wales— Heavy steel		1 17 6
Bundled steel and shrngs.	1 14 0	to 1 17 0
Mixed iron and steel	1 10 0	to 1 14 0
Heavy cast iron	1 17 0	to 1 19 0
Good machinery		2 5 0
Cleveland— Heavy steel	1 12 6	to 1 15 0
Steel turnings		1 7 6
Cast-iron borings		1 2 6
Heavy forge		2 10 0
W.I. piling scrap		2 2 6
Cast-iron scrap	1 15 0	to 1 16 0
Midlands— Light cast-iron scrap		1 15 6
Heavy wrought iron		2 2 6
Steel turnings, f.o.r.		0 19 0
Scotland— Heavy steel		1 12 6
Ordinary cast iron		1 19 0
Engineers' turnings		1 7 6
Cast-iron borings		1 10 0
Wrought-iron piling		1 19 0
Heavy machinery		2 4 0

London—Merchants' buying prices delivered yard.

	£ s. d.
Copper (clean)	25 0 0
Brass	17 0 0
Lead (less usual draft)	10 10 0
Tea lead	9 0 0
Zinc	8 10 0
New aluminium cuttings	72 0 0
Braziery copper	22 0 0
Gunmetal	21 0 0
Hollow pewter	82 0 0
Shaped black pewter	65 0 0

PIG-IRON.

(f.o.t. unless otherwise stated.)

N.E. Coast— Foundry No. 1	61/-
Foundry No. 3	58/6
Foundry No. 4	57/6
Forge No. 4	57/-
Hematite No. 1	59/6
Hematite M/Nos.	59/-
N.W. Coast— Hem. M/Nos. d/d Glas.	70/-
d/d Birm.	84/6
Malleable iron d/d Birm.	117/6
Midlands— Staffs No. 4 forge*	61/-
No. 3 fdry.*	66/-
Shrops basic	—
Cold blast, ord.	—
roll iron	—
Northants forge*	57/6
fdry. No. 3*	62/6
fdry. No. 1*	65/6
Derbyshire forge*	61/-
fdry. No. 3*	66/-
fdry. No. 1*	69/-
basic*	—

*d/d Black Country dist.

Scotland— Foundry No. 1	70/-
No. 3	67/6
Hem. M/Nos. d/d	67/6
Sheffield (d/d district)— Derby forge	58/6
fdry. No. 3	63/6
Lincs forge	—
fdry. No. 3	63/6
E.C. hematite	73/6
W.C. hematite	83/6
Lancashire (d/d eq. Man.)— Derby forge	62/-
fdry. No. 3	67/-
Staffs fdry. No. 3	67/-
Northants fdry. No. 3	65/6
Cleveland fdry. No. 3	67/-
Dalzell, No. 3 (special)	102/6 to 105/-
Glengarnock, No. 3	83/- to 84/-
Clyde, No. 3	83/- to 84/-
Monkland, No. 3	83/- to 84/-
Summerlee, No. 3	83/- to 84/-
Eglinton, No. 3	83/- to 84/-
Gartsherrie, No. 3	83/- to 84/-
Shotts, No. 3	83/- to 84/-

FINISHED IRON AND STEEL.

Usual District deliveries for iron; delivered consumers' station for steel.

	£ s. d.	£ s. d.
Iron— Bars (or.)	9 0 0	to 9 15 0
Nut and bolt iron	7 15 0	to 8 10 0
Hoops	10 10 0	to 12 0 0
Marked bars (Staffs) f.o.t.		12 0 0
Gas strip	10 10 0	to 12 0 0
Bolts and nuts, ½ in. × 4 in.		12 5 0
Steel— Plates, ship, etc.	8 15 0	to 8 17 6
Boiler plts.	8 7 6	to 9 5 0
Chequer plts.		10 7 6
Angles		8 7 6
Tees		9 7 6
Joists		8 15 0
Rounds and squares, 3 in. to 5½ in.		9 7 6
Rounds under 3 in. to ¼ in. (Untested)	6 15 0	& up.
Flats—8 in. wide and over		8 12 6
under 8 in. and over 5 in.		8 17 6
Rails, heavy	8 5 0	to 8 10 0
Fishp ates		12 0 0
Hoops (Staffs)	9 10 0	to 10 10 0
Black sheets, 24g. (10-t. lots)		9 5 0
Galv. cor. shts.		11 5 0
Galv. flat shts.		11 15 0
Galv. fencing wire, 8g. plain		14 0 0
Billets, soft	4 17 6	to 5 7 6
Billets, hard	6 12 6	to 7 2 6
Sheet bars	4 12 6	to 5 2 6
Tin bars	4 12 6	to 4 15 0

PHOSPHOR BRONZE.

	Per lb. basis.
Strip	10¾d.
Sheet to 10 w.g.	11½d.
Wire	11½d.
Rods	10¾d.
Tubes	16¾d.
Castings	12¾d.

Delivery 3 cwt. free.
10% phos. cop. £30 above B.S.
15% phos. cop. £35 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. Clifford & Son, Limited.

NICKEL SILVER, &c.

	Per lb.
Ingots for raising	7d. to 1/1
Rolled— To 9 in. wide	1/1 to 1/7
To 12 in. wide	1/1½ to 1/7½
To 15 in. wide	1/1½ to 1/7½
To 18 in. wide	1/2 to 1/8
To 21 in. wide	1/2½ to 1/8½
To 25 in. wide	1/3 to 1/9
Ingots for spoons and forks	7d. to 1/3½
Ingots rolled to spoon size	10d. to 1/6½
Wire round— to 10g.	1/4½ to 1/11½

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/3½ upwards.

AMERICAN IRON AND STEEL.

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	13.84
No. 2 foundry, Valley	14.50
No. 2 foundry, Birm.	11.00
Basic	15.39
Bessemer	16.89
Malleable	16.39
Grey forge	16.39
Ferro-mang. 80%, seaboard	68.00
O.-h. rails, h'y, at mill	40.00
Billets	26.00
Sheet bars	26.00
Wire rods	37.00
	Cents.
Iron bars, Phila.	2.11
Steel bars	1.60
Tank plates	1.60
Beams, etc.	1.60
Skelp, grooved steel	1.60
Steel hoops	1.55
Sheets, black, No. 24	2.20
Sheets, galv., No. 24	2.85
Wire nails	1.95
Plain wire	2.20
Barbed wire, galv.	2.60
Tinplates, 100-lb. box	$4.75

COKE (at ovens).

Welsh foundry	20/- to 22/6
furnace	16/- to 16/6
Durham and Northumberland— foundry	21/- to 25/-
furnace	12/- to 12/6
Midlands, foundry	—
furnace	—

TINPLATES.

f.o.b. Bristol Channel ports.

I.C. cokes 20×14 per box	15/9 to 16.3
28×20 „	31/6 to 32/6
20×10 „	22/7½ to 23/-
18¾×14 „	16/4½ to 16/7½
C.W. 20×14 „	13/6 to 14/-
28×20 „	—
20×10 „	—
18¾×14 „	—

SWEDISH CHARCOAL IRON & STEEL.

Pig-iron	£6 0 0 to £7 0 0
Bars-hammered, basis	£16 10 0 to £17 0 0
Bars and nail-rods, rolled, basis	£15 17 6 to £16 5 0
Blooms	£10 0 0 to £12 0 0
Keg steel	£32 0 0 to £33 0 0
Faggot steel	£18 0 0 to £23 0 0
Bars and rods dead soft, st'l	£10 0 0 to £12 0 0

All per English ton, f.o.b. Gothenburg.
[Subject to an exchange basis of Kr. 18.16 to £1.]

DAILY FLUCTUATIONS.

Standard Copper (cash).

		£	s.	d.	
Oct. 27 ..		30	11	3	dec. 1/3
„ 28 ..		30	10	0	„ 1/3
„ 31 ..		30	5	0	„ 5/-
Nov. 1 ..		30	5	0	No change
„ 2 ..		29	18	9	dec. 6/3

Electrolytic Copper.

		£	s.	d.	
Oct. 27 ..		35	0	0	No change
„ 28 ..		35	0	0	„ „
„ 31 ..		35	5	0	inc. 5/-
Nov. 1 ..		35	5	0	No change
„ 2 ..		34	15	0	dec. 10/-

Standard Tin (cash).

		£	s.	d.	
Oct. 27 ..		152	17	6	inc. 15/-
„ 28 ..		152	17	6	No change
„ 31 ..		152	10	0	dec. 7/6
Nov. 1 ..		152	5	0	„ 5/-
„ 2 ..		152	2	6	„ 2/6

Tin (English ingots).

		£	s.	d.	
Oct. 27 ..		153	10	0	inc. 17/6
„ 28 ..		153	10	0	No change
„ 31 ..		153	5	0	dec. 5/-
Nov. 1 ..		152	15	0	„ 10/-
„ 2 ..		152	15	0	No change

Spelter (ordinary).

		£	s.	d.	
Oct. 27 ..		15	1	3	No change
„ 28 ..		15	2	6	inc. 1/3
„ 31 ..		15	2	6	No change
Nov. 1 ..		15	1	3	dec. 1/3
„ 2 ..		15	2	6	inc. 1/3

Spelter (Electro, 99.9 per cent.).

		£	s.	d.	
Oct. 27 ..		17	12	6	inc. 2/6
„ 28 ..		17	12	6	No change
„ 31 ..		17	12	6	„ „
Nov. 1 ..		17	7	6	dec. 5/-
„ 2 ..		17	7	6	No change

Zinc Sheets (English).

		£	s.	d.	
Oct. 27 ..		24	10	0	No change
„ 28 ..		24	10	0	„ „
„ 31 ..		24	10	0	„ „
Nov. 1 ..		24	10	0	„ „
„ 2 ..		24	10	0	„ „

Lead (English).

		£	s.	d.	
Oct. 27 ..		13	10	0	No change
„ 28 ..		13	10	0	„ „
„ 31 ..		13	10	0	„ „
Nov. 1 ..		13	10	0	„ „
„ 2 ..		13	10	0	„ „

AVERAGE MONTHLY PRICES OF DERBYSHIRE NO. 3 FOUNDRY AT MANCHESTER.

Year.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1896	2 5 6	2 6 0	2 6 0	2 6 0	2 6 0	2 5 6	2 5 0	2 5 0	2 5 0	2 6 0	2 7 0	2 8 6	2 5 11½
1897	2 10 0	2 11 0	2 9 0	2 8 6	2 8 0	2 7 0	2 7 0	2 7 0	2 6 0	2 6 0	2 6 6	2 7 6	2 7 9½
1898	2 7 6	2 8 0	2 8 0	2 8 6	2 8 6	2 10 0	2 10 0	2 10 0	2 10 0	2 11 0	2 14 0	2 14 0	2 9 11
1899	2 13 0	2 14 0	2 14 0	2 14 0	3 0 0	3 2 0	3 13 0	3 16 6	3 15 0	3 16 6	3 16 6	4 0 0	3 6 2½
1900	4 0 0	4 0 0	4 0 0	4 1 6	4 1 0	3 18 0	3 13 6	3 12 6	3 11 0	3 11 0	3 9 6	3 8 0	3 15 5
1901	2 13 6	2 17 0	2 15 0	2 15 0	2 14 0	2 13 9	2 13 6	2 13 6	2 14 6	2 13 0	2 12 6	2 16 6	2 14 3½
1902	2 17 6	2 17 6	2 15 6	2 16 9	2 16 6	2 16 6	2 16 6	2 17 0	2 18 6	2 18 6	2 17 6	2 17 6	2 17 1½
1903	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6
1904	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6
1905	2 13 0	2 13 0	2 11 6	2 12 6	2 12 0	2 12 0	2 12 3	2 12 3	2 14 0	2 16 6	3 0 0	3 0 6	2 14 1
1906	3 2 0	3 5 0	3 3 0	3 0 6	2 17 0	2 18 6	2 18 0	2 16 6	2 19 0	3 0 6	3 1 6	3 7 0	3 0 8½
1907	3 7 0	3 7 0	3 5 0	3 2 0	3 4 0	3 8 0	3 6 0	3 5 0	3 4 0	3 2 6	3 1 0	2 18 6	3 4 2
1908	2 15 0	2 14 0	2 14 6	2 15 6	2 14 0	2 13 0	2 13 0	2 11 6	2 12 6	2 13 0	2 12	2 12 6	2 13 5½
1909	2 13 0	2 12 6	2 11 6	2 12 0	2 12 6	2 12 6	2 12 0	2 12 6	2 14 6	2 15 0	2 14 6	2 14 0	2 13 0½
1910	2 13 9	2 14 0	2 14 0	2 14 4	2 15 0	2 15 0	2 14 9	2 15 0	2 15 0	2 15 0	2 15 0	2 15 0	2 14 7½
1911	2 16 0	2 16 0	2 16 0	2 16 0	2 16 0	2 16 0	2 16 0	2 16 0	2 16 0	2 14 6	2 15 0	2 15 0	2 15 8½
1912	2 17 4½	2 17 6	2 17 6	3 1 1½	3 2 6	3 3 9	3 6 3	3 7 6	3 10 10½	3 12 6	3 13 3½	3 14 6	3 5 4
1913	3 15 7	3 15 0	3 11 10½	3 11 4½	3 10 2½	3 6 10½	3 4 2½	3 2 9	3 1 9	3 1 0	2 19 3	2 17 2½	3 6 5
1914	2 17 2½	2 18 0	2 18 0	2 17 0	2 17 0	2 16 7½	2 16 0	3 2 10	3 1 0	2 19 9½	2 16 11½	2 18 1½	2 18 2
1915	3 1 2	3 3 11	3 5 9	3 18 8½	3 13 7	3 14 1	3 15 0	3 13 3	3 12 0½	3 11 1	3 14 0	4 3 3	3 12 2½
1916	4 4 6½	4 11 6	4 11 6½	4 7 6	4 7 6	4 7 6	4 10 0	4 12 10	4 12 6	4 12 6	4 12 6	4 12 6	4 8 6½
1917	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6
1918	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6
1919	4 12 6	4 12 6	4 12 6	4 12 6	7 2 6	7 5 0	8 8 5	9 0 0	9 0 0	9 0 0	9 0 0	9 0 0	7 3 10
1920	9 13 9	10 0 0	10 5 3	10 15 3	11 10 0	12 2 6	12 5 0	13 1 3	14 7 6	14 5 0	14 5 0	14 5 0	12 12 1½
1921	12 11 8	10 8 9	9 2 6	8 2 0	8 0 0	8 0 0	8 0 0	8 1 8	7 4 0	6 7 6	5 7 6	4 16 10	8 0 2
1922	5 5 0	4 17 6	4 15 0	4 15 0	4 12 6	4 12 6	4 12 6	4 12 6	4 11 3	4 10 0	4 10 0	4 10 0	4 13 7½
1923	4 12 8½	5 0 2	6 2 6	6 8 7½	6 2 5	5 11 9	5 9 1½	5 4 0	5 0 0	5 0 9	5 0 7	5 2 9	5 7 11½
1924	5 3 0	5 3 0	5 3 0	5 3 0	5 2 10	5 1 3	4 17 11	4 15 6	4 13 6	4 10 1½	4 10 0	4 10 3	4 17 9½
1925	4 10 0	4 9 0	4 6 9	4 5 2½	4 3 0	4 0 1½	4 17 1½	3 15 7½	3 14 3½	3 13 4½	3 13 4½	3 13 2½	4 1 9
1926	3 14 9	3 15 3	3 15 6	3 15 3½	3 17 6	4 5 9	4 16 9	*	*	*	*	4 12 6	4 0 1½
1927	4 13 9½	4 13 3	4 11 1½	4 9 4½	4 6 1½	3 19 1½	3 16 1½	3 15 6	3 13 4½	3 13 4½	3 14 0	3 13 6½	4 1 6½
1928	3 13 2½	3 12 3½	3 12 3	3 12 3	3 11 6	3 10 0	3 8 3	3 7 8½	3 7 6	3 7 9½	3 8 3	3 7 6	3 9 10½
1929	3 8 3½	3 10 4½	3 10 10½	3 11 0	3 11 2½	3 12 0	3 12 4½	3 14 6	3 15 1½	3 17 0	3 17 0	3 17 0	3 13 1½
1930	3 17 0	3 17 0	3 17 0	3 17 0	3 17 0	3 17 0	3 15 0	3 12 0	3 12 0	3 12 0	3 10 1½	3 9 6	3 14 4½
1931	3 9 6	3 9 6	3 9 6	3 9 6	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 10
1932	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	—	—	—

* No prices available during strike period.

WILLIAM JACKS & COMPANY,

WINCHESTER HOUSE, OLD BROAD ST., LONDON, E.C.2.

CLARENCE CHAMBERS, 39, CORPORATION STREET, BIRMINGHAM.

13, RUMFORD STREET, LIVERPOOL.

PIG IRON

REGISTERED TRADE MARK

All grades FOUNDRY, HEMATITE, BASIC, SPECIALS, &c.

NON-FERROUS METALS

COPPER, TIN, LEAD, SPELTER, ANTIMONY, CHROME ORE.

WILLIAM JACKS & COMPANY,

CENTRAL CHAMBERS, 93, HOPE ST., GLASGOW, C.2.

ZETLAND ROAD, MIDDLESBROUGH.

SMALL ADVERTISEMENTS.

Notice.

Small Advertisements in this section of the Journal are accepted at the prepaid rate of 6d. per line, first line in capitals counting two, average 6 words per line. Minimum charge for one insertion 3/-

(A remittance should accompany instructions.)

SITUATIONS WANTED.

ADVERTISER desires position as Foundry Manager or Foreman; practical, technical and commercial training all branches foundry work; thorough knowledge of metallurgy and mixing of metals, and can guarantee results.—Box 274, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

BRASS FOUNDRY FOREMAN desires position; experienced in Admiralty contracts, gunmetal, phos. bronze and manganese castings; 12 years foreman in last situation.—Box 258, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

EMPLOYMENT REGISTER.

Conducted by the Institute of British Foundrymen by courtesy of the proprietors of THE FOUNDRY TRADE JOURNAL.

Correspondence should be addressed to the General Secretary, Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester, from whom full particulars can be obtained of this service.

Any employer wishing to communicate with a candidate should write to the General Secretary, quoting identification number.

LIFELONG practical experience as Chargehand and Foreman in marine engineering and jobbing work, including green-sand, dry-sand, loam moulding, oil-sand coremaking, and long experience in cupola practice. Thorough practical knowledge in drawings and calculations. Age 42. (194)

PROPERTY.

MAGNIFICENT

11 ACRES WORKS SITE.

SHEFFIELD.

145,000 Sq. Ft. of Shops.

SIDING CONNECTIONS

with L.M. & S. and L. & N.E. Rlys.

WELL-BUILT & COMMODIOUS OFFICES

Will Sell whole or in lots to suit customers or Let on favourable terms. Unique opportunity for Manufacturers.

Apply—

THOS. W. WARD, LTD.,

ALBION WORKS, SHEFFIELD.

MACHINERY.

6-FT. x 6-ft. x 8-ft. Tilghman Sandblast Room, complete with all equipment and Tilghman Air Compressor. Cheap for quick sale.—A. HAMMOND, Foundry Machinery Merchant, Slough.

MACHINERY—*Continued.*

FOR Sale, 3-ton "Titan" Cupola, Staging, Roof, Hand Hoist, Fan and Motor, forming complete melting unit, all by Constructional Engineering Company, Limited. In very good condition; sale, cheap.—Box 278, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

TILGHMAN SAND-BLAST ROOM, 12 ft. x 9 ft., in C.I. Sections.

Tilghman Rotary Barrel SAND-BLAST PLANT, 36 in. x 30 in. Complete with Tilghman B.H. 4½ Compressor.

Macdonald No. 9 "Ajax" Pneumatic Jarr Turnover P.D. MOULDING MACHINE.

Fordath "Senior" Rotoil Core SAND MIXER.

Pneulec Royer No. 1 SAND MIXER.

Pridmore Rockover Portable MOULDING MACHINE.

Twenty Adaptable Hand MOULDING MACHINES, latest type.

Tabor Pneumatic Split Pattern Squeezer. New.

No. 1 Britannia Jolters.

Tabor Pneumatic Portable Rollover MOULDING MACHINE.

Jackman 2-ton Geared LADLE. New.

K.B. ELECTRIC BLOWERS, 220 volts D.C., 6-in. and 8-in. outlet. New.

Numerous other items of Foundry Plant, also Air Compressors and Electric Motors, in stock. ALL AT LOW PRICES.

Send your inquiries to:—S. C. BILSBY, A.M.I.C.E., 215, Barclay Road, Warley, near Birmingham. 'Phone: Bearwood 1103.

12-FT. x 9-ft. Tilghman Sandblast Room, complete with all equipment and Tilghman Air Compressor. Cheap for quick sale.—A. HAMMOND, Foundry Machinery Merchant, Slough.

S. C. BILSBY, A.M.I.C.E., A.M.I.E.E.

Carries a large stock of **FOUNDRY PLANT** which, generally, includes:—

Power and Hand Moulding Machines, Sand Mills and Disintegrators, Sand Blast Plants, Ladles, Melting Furnaces, Grinding Machines, Blowers and Exhaust Fans, Air Compressors, etc., etc.

Also 300 A.C. and D.C. Electric Motors, ¼ to 200 h.p., and Generators, to suit most systems.

All at low prices. Please send your inquiries to:—

215, BARCLAY ROAD, WARLEY,
Nr. Birmingham.
'Phone: Bearwood 1103.

WORKS ADDRESS: Crosswells Road (next G.W.R. level crossing), Langley, near Birmingham. 'Phone: Broadwell 1359.

THOS. W. WARD, LTD.

Sykes No. 4 Straight Tooth Gear Shaper, cap. 52" x 8".

High-speed Rack-driven Planer, cap. 11' 6" x 4' 1" x 4' 1".

Hori. Plano Miller, slotted table 13' 3" x 3' 7".

9" Rotary Bar Cutting-off Machine.

VERT. COCHRAN BOILER, 14' x 7', 100 lbs. w.p.

ALBION WORKS, SHEFFIELD.

'Grams: Forward. 'Phone, 23001 (10 lines).

"Albion" Catalogue on application.

MACHINERY—*Continued.*

TWO SMALL Turnover Machines by OSBORN

One LARGE Turnover Machine by OSBORN. Cheap for quick sale. Practically new.

A. HAMMOND,
Foundry Machinery Merchant, Slough.

'Phone: 287 SLOUGH

SAND PLANT

"Rotoil" Oilsand mixer, large size	£60
"Spermolin" paddle-blade Oilsand mixer, large size	£18
"Herbert" Sand disintegrator ...	£32
Ronceray "continuous" 60" mill	£40

PNEUMATIC MACHINES

14"×16" Mumford split pattern 2@£30 each	
18"×18" Tabor split pattern ...	£40
30"×20" Macdonald jolt rollover...	£60
20"×16" Macdonald jolt rollover...	£40

AIR COMPRESSORS
ALL SIZES IN STOCK.

Every Machine overhauled and retested.

BUY FROM ME AND SAVE MONEY!

ALEX. HAMMOND, *Foundry Machinery Merchant,*
14, AUSTRALIA ROAD, SLOUGH

To Engineers, Founders, Manufacturers. Fine site of nearly 3 acres on Arterial Road with Foundry and Workshops and own Rail Sidings into premises. Modern Offices, Warehouse and Workrooms. Central Heating.

CHARLES A. TRICKS & SON,
Auctioneers,
ST. NICHOLAS STREET, BRISTOL.

Bradley's

REFINED
ALLOY IRONS

A new range of compositions containing varying proportions of Nickel, Chromium, Vanadium, Titanium, etc., suitable for wear and corrosion resistance, castings required to withstand high temperature, acid resistance and for high strength, toughness and resilience qualities. The use of Alloy Pig Irons ensures homogeneous castings, avoids segregation and ladle losses and gives 100% benefit from alloy additions.

BRADLEY & FOSTER LIMITED
DARLASTON BLAST FURNACES,
DARLASTON, STAFFS

Telephone: Darlaston 16 (P.B. Ex.) Telegrams: "Bradley's, Darlaston."

INOKULITE (Regd.)
(The Germ Process)
CONTROLS THE FORMATION OF GRAPHITE IN ALL CAST AND MALLEABLE IRONS—PREVENTS CHILL AND INCREASES STRENGTH AND WEAR.

Sole Manufacturers: **BEECROFT & PARTNERS, Ltd.,**
Retort Works, Mappin Street, SHEFFIELD.

FOR ACCURATE AND SPEEDY ANALYSIS SEND YOUR *SAMPLES TO*— **BEECROFT & PARTNERS, LTD.,**

"The Foundry Chemists," Laboratories and Testing Works. St. Peter's Close, SHEFFIELD.

ANALYSIS PHYSICAL TESTING METALLOGRAPHY
FOUNDRY CONSULTATIONS SAMPLING, Etc., Etc.